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SUBHUL: SUBMARINE PRESSURE HULL FINITE ELEMENT MODEL GENERATOR. USER'S MANUAL

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SUBHUL

SUBMARINE PRESSURE HULL FINITE ELEMENT MODEL GENERATOR USER'S MANUAL

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ABSTRACT

59 A user's manual for the submarine pressure hull finite element model generator program SUBHUL is presented. SUBHUL has been designed to produce model, mass, boundary condition, and load files for the finite element program VAST. The manual describes typical submarine geometry and structural details. Organization of the program is given along with the procedure for model generation. Hard copies of terminal session prompts and responses are included to illustrate the use of the program. The VAST input files produced by SUBHUL are described. Examples of stress, buckling, and vibration analysis using VAST are provided with the results illustrated in the form of graphic output.//

RÉSUMÉ

On présente un guide de l'utilisateur portant sur le logiciel SUBHUL, un générateur de modéles á éléments finis de coques épaisses de sous-marines. SUBHUL a été conçu pour produire des fichiers de données relatives aux modéles, aux masses, aux conditions aux limites et aux charges destinés au logiciel d'analyse par éléments finis VAST. Le guide décrit des structures et des formes géométriques de sous-marines types. Il montre l'organisation du logiciel et la méthode de génération de modéles. Il comprend des copies sur papier des messages de guidage et des réponses d'une séance d'utilisation du terminal qui illustrent l'utilisation du programme. Une description des fichiers d'entrée de VAST qui sont produits par SUBHUL est fournie. Des exemples d'analyses des contraintes, du flambement et des vibrations réalisées á l'aide de VAST sont présentés avec les résultats sous forme graphique.

TABLE OF CONTENTS

Page No.

CHAPTER 1

1. INTRODUCTION

SUBHUL is a finite element model generator program for modelling submarine pressure hulls. Three model types can be generated. One is a flat deck pressure hull model typical of older submarines (Figure 1.1). The second is an axisymmetric stepped configuration (Figure 1.2). The third model type is a smooth axisymmetric curve form more typical of the modern submarine (Figure 1.3).

The model data are generated in the format of the input data for the finite element program VAST (Reference 1) through which hull collapse, in the form of bifurcation buckling, can be assessed. Vibration modes of the hull can also be predicted along with displacements and stresses due to hydrostatic loading. Nonlinear effects such as post buckling behaviour are accounted for by use of an interface program ADIDAT, which can convert the VAST model in to the format required by the nonlinear finite element analysis program ADINA (Reference 2). In addition, SUBHUL can generate a PATRAN (Reference 3) phase 1 and phase 2 data file directly. Indirectly, a phase 2 PATRAN data file can be produced by the use of a VAST to PATRAN translator program VASPAT. (Reference 4). This translator is able to convert VAST analysis results so the PATRAN pre and post- processors can be used to augment those available in the VAST suite of auxiliary programs.

In determining vibration frequencies the added mass of the surrounding water is accounted for by two methods. One method models the water by using fluid finite elements. The alternate method uses a distribution of panels,which match the finite element grid of the pressure hull shell. It is based on a surface panel singularity distribution method, Reference 5, which does not require discretization of the fluid.

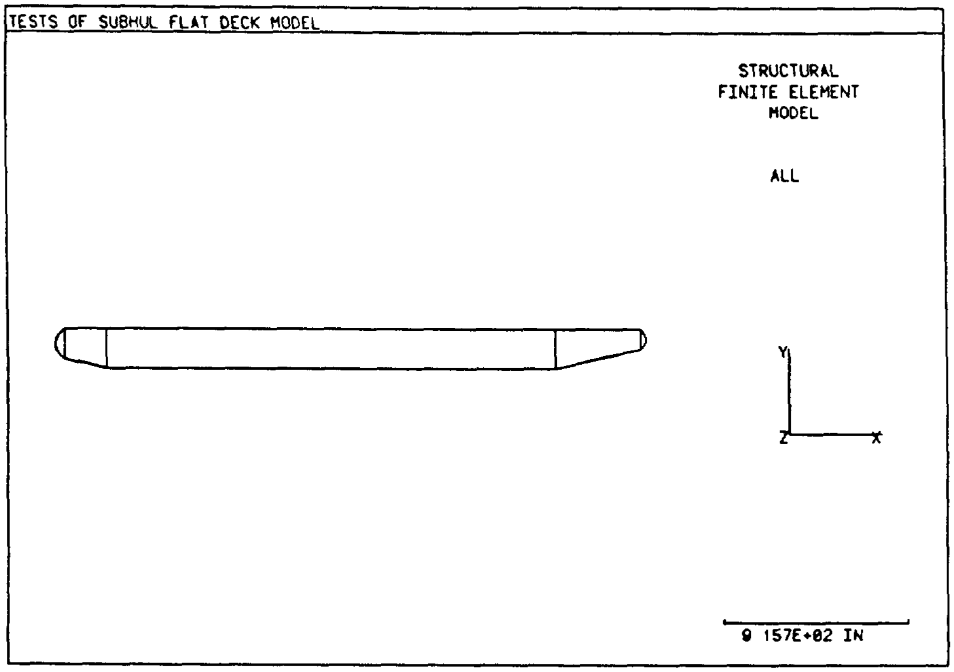


Figure 1.1 Flat Deck Submarine Pressure Hull Model

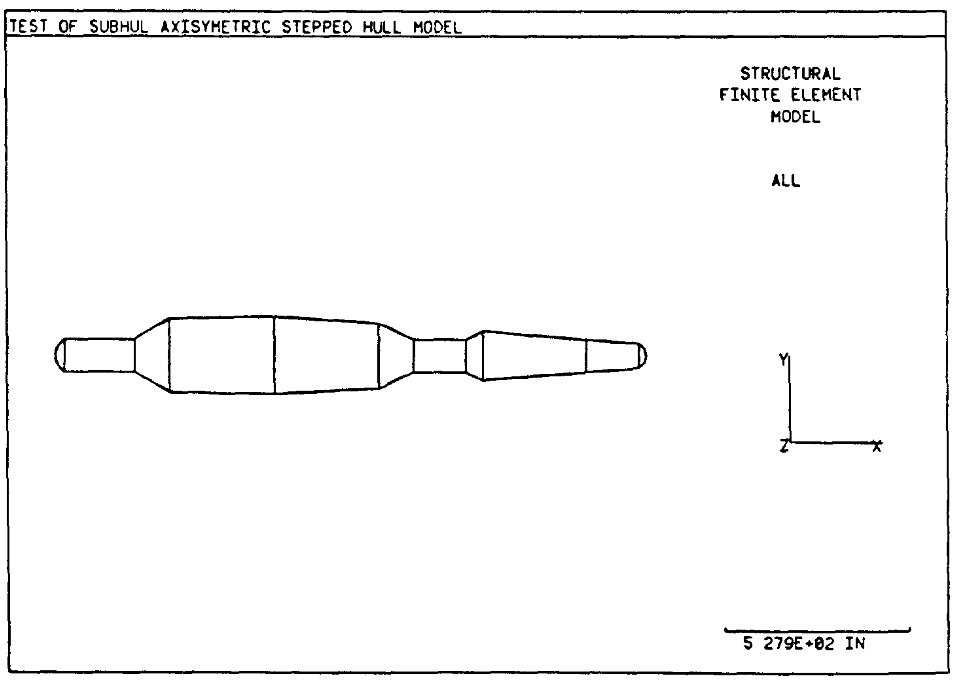


Figure 1.2 Axisymmetric Stepped Pressure Hull Model

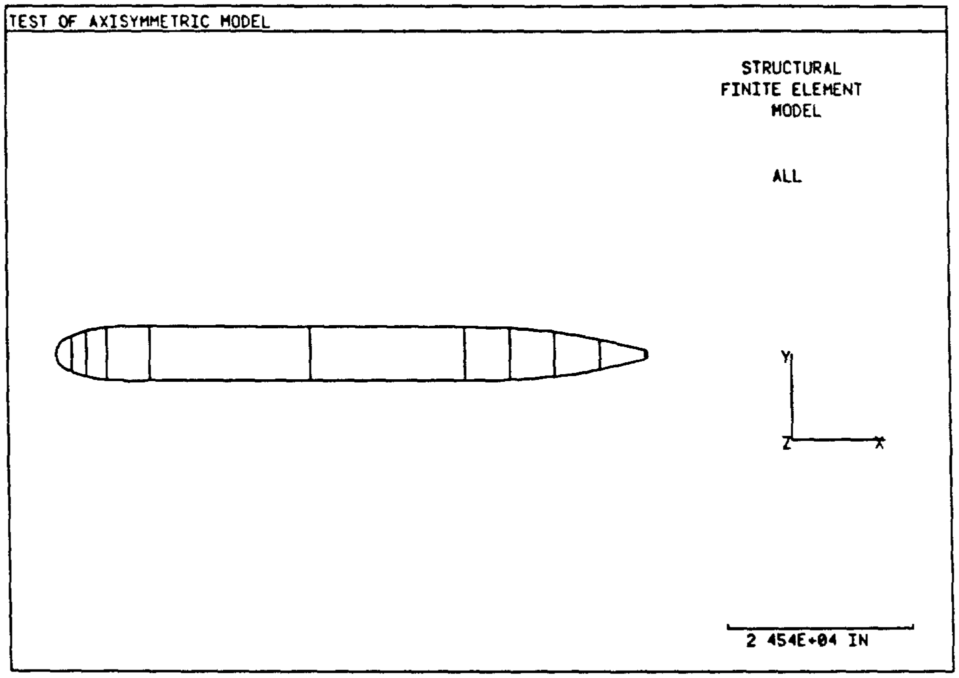


Figure 1.3 Axisymmetric Smooth Outline Pressure Hull Model

CHAPTER 2

1. SUBMARINE STRUCTURAL DETAILS

A submarine structure is basically a ring stiffened cylinder surrounded by hydrodynamic fairings. The configuration of an older submarine and that of a modern submarine are shown in Figures 2.1a and 2.1b. Attached to the stiffened cylinder or pressure hull are the control appendages such as the rudder and diving planes. The fairings are free flooding. The pressure hull, on the other hand, must withstand the hydrostatic pressure at the design diving depth. Within the fairings are the ballast tanks (Figure 2.2). On older designs ballast tanks increase the overall diameter. In modern submarines the pressure hull is locally reduced in diameter to accommodate them(Figure 2.3).

SUBHUL is mainly concerned with producing models of the pressure hull so that predictions of collapse strength and structural vibrations can be made. Maximum structural efficiency is obtained by constructing the hull in the form of a cylindrical shell, stiffened by many evenly spaced ring frames or stiffeners. The ring stiffeners can be placed on the inside or outside of the hull depending on the situation (Figure 2.4). The cylindrical shell is capped by enclosures which are generally hemispherical in shape, although other shapes are used. Many of the frames are T sections of the same size welded to the hull shell.

The pressure hull is divided into compartments by bulkheads which may or may not be pressure resistant. Ring frames much larger than the normal frame may also be distributed along the hull in place of bulkheads to allow for larger compartments (Figure 2.5). General collapse occurs between bulkheads and the large ring frames and is an important factor in deciding compartment length. Interframe collapse between ring frames is a second buckling mode which governs ring spacing.

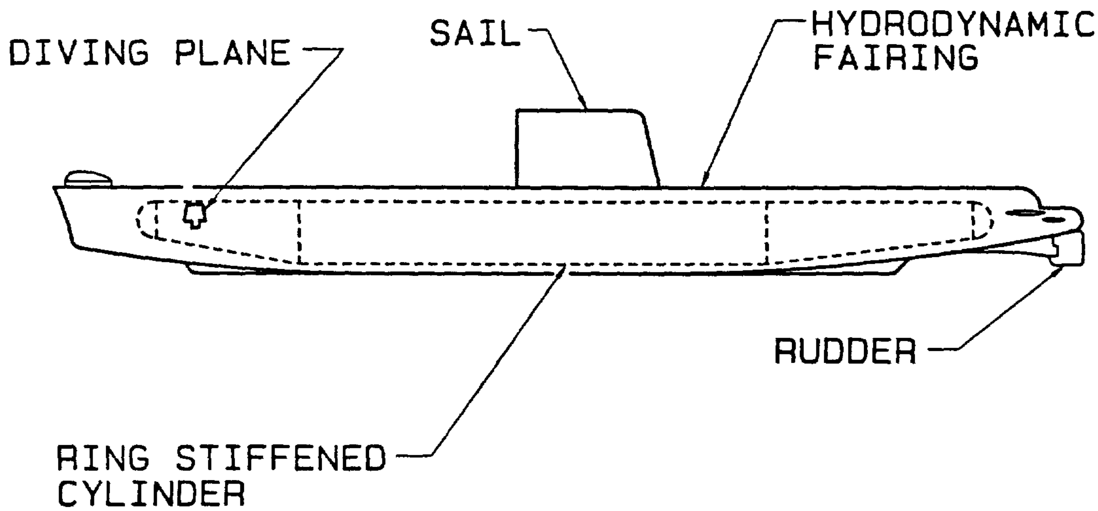


Figure 2.1a Older Submarine Configuration

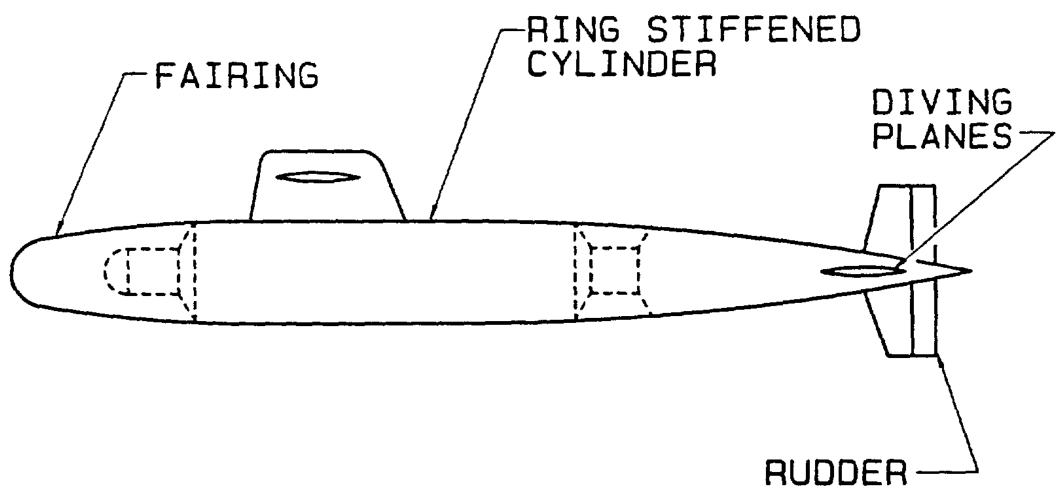


Figure 2.1b Modern Submarine Configuration

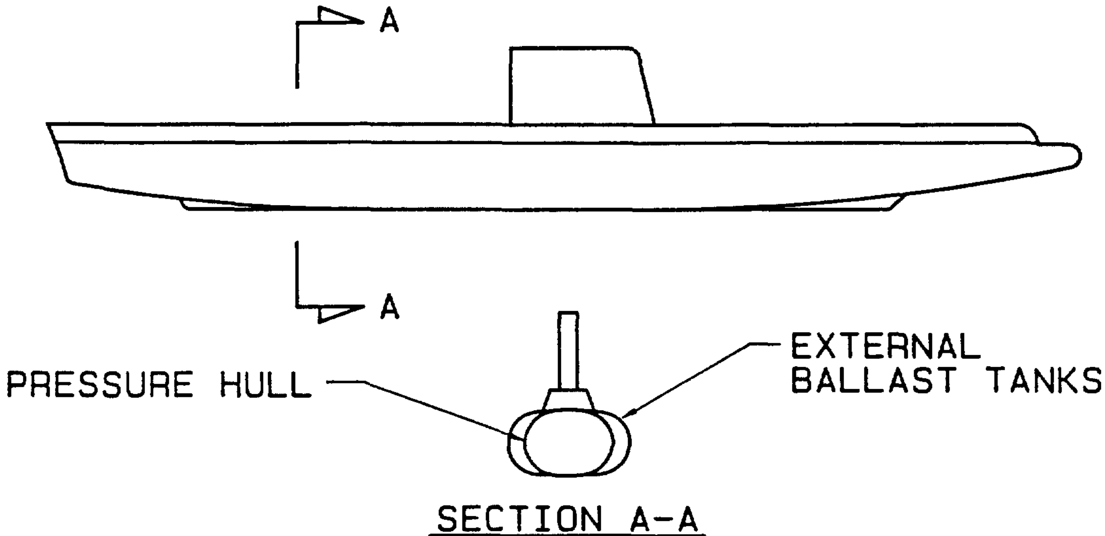


Figure 2.2 External Ballast Tanks

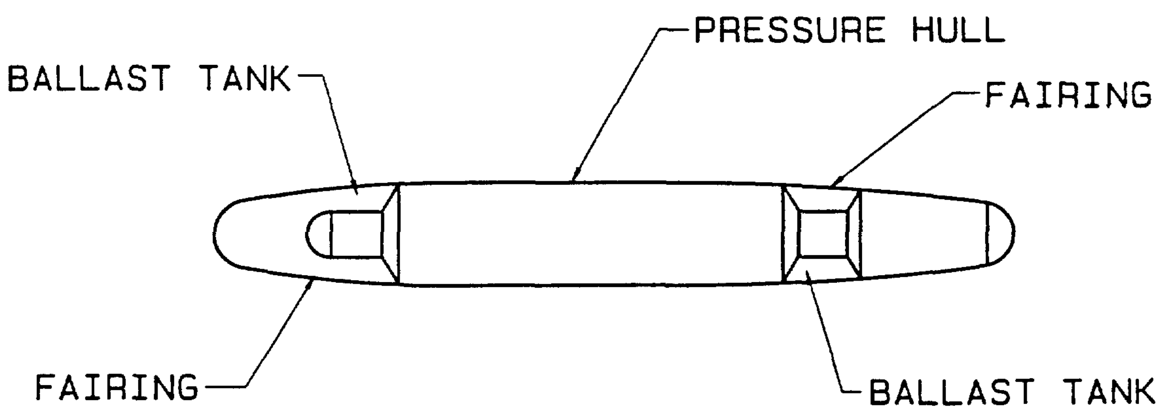


Figure 2.3 Ballast Tanks Formed by Local Reduction of the Pressure Hull

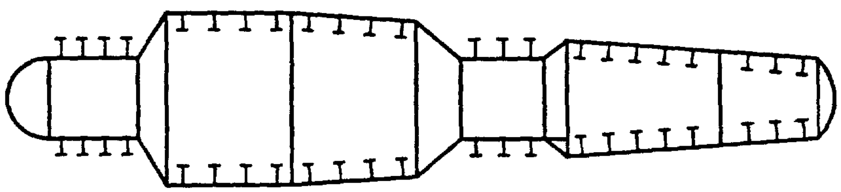


Figure 2.4 Ring Stiffeners on Inside and Outside of Pressure Hull

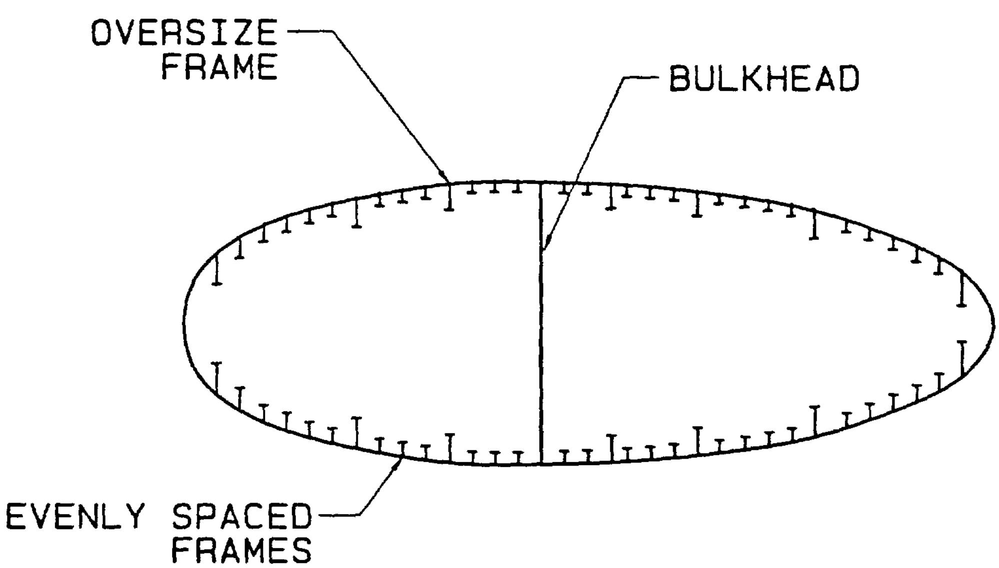


Figure 2.5 Oversize Ring Frames and Bulkheads

CHAPTER 3

3. PROGRAM ORGANIZATION

3.1 General Description

SUBHUL is organized to generate finite element model files of a submarine pressure hull (Figure 3.1). A unique five character prefix is assigned to the files for each model. These files can be read by SUBHUL itself and by graphic and finite element analysis programs such as VAST, PATRAN and VASTG. The basic data file, PREFX.DAT, is generated by SUBHUL from terminal input. It contains the basic geometry of the pressure hull. This file can be edited by SUBHUL when changes in the basic geometry are required.

Once the basic data have been entered, the program prompts the user for information concerning ring stiffeners and bulkheads and the number of elements in the circumferential direction and between stiffeners. These data are stored on the model description file, PREFX.LPR, which in hardcopy form is a useful reference for the user. Simultaneously, a finite element model file, PREFX.SBH, is created, which contains all the coordinates and element specifications for model generation. There is also an option in this phase to create a PATRAN session file, PREFX.SES for geometry display and verification. The user may stop or continue at this stage. If stop is chosen all the generated files are saved. On restart, SUBHUL will retrieve the required data from the PREFX.SBH file and continue on with user input to produce, as required, a VAST geometry file, PREFX.GOM, a boundary condition file PREFX.SMD, and a load file PREFX.LOD. If residual stress is to be accounted for, the user can generate a PREFX.STR file of known nodal point residual stresses.

In the case of a vibration analysis, a mass file, PREFX.MMD, and an added mass file, PREFX.AMD, will be created. Thus once PREFX.SBH has been generated, SUBHUL can be restarted at any time as the finite element model is available for assessing different load cases and changes to mass or boundary conditions. If the finite element model must be modified, it is necessary to go back to the PREFX.DAT file and regenerate PREFX.SBH. On completion of the terminal session the PREFX.USE file is produced, which contains the master control codes for a finite analysis using VAST.

3.2 Auxiliary Programs

The files produced by SUBHUL serve as input for a number of programs as illustrated in Figure 3.1. These programs are:

VAST

This is a general purpose finite element program around which SUBHUL has been designed. From the SUBHUL generated files, VAST can predict stresses in the pressure hull when subjected to hydrostatic and concentrated loads (Reference 1). VAST can also predict structural instability and vibrations. The effect of the added fluid mass and the ambient hydrostatic pressure on the vibration frequencies can be modelled. More complex analyses can be performed such as response to dynamic loads, frequency response and response spectrum analysis. The generation of dynamic loading is beyond the current capabilities of SUBHUL, but may be accomplished through the use of the VAST user's manual (Reference 1).

VASTG

Graphic display of the pressure hull finite element model, mass locations, boundary conditions and the added mass modelling, can be made in SUBHUL by calls to the VAST graphics program VASTG (Reference 6). External to SUBHUL, VASTG can be used to display the loads and analytical results of a VAST analysis in the form of plots of load vectors, stress contours, displacements and vibration mode shapes.

VASTBC

Boundary conditions can be applied to the model interactively with the program VASTBC (Reference 7) by displaying the finite element model on the screen and locating the constraints with the screen cursor. The program can be called from within SUBHUL or used externally.

PATRAN

PATRAN (Reference 3) is a general purpose finite element model generator. Although the pressure hull finite element model and the VAST analytical results can be displayed by VASTG there are advantages in being able to use the power of PATRAN's graphics, which include color, shading, element identification by color, color fringe plots of stresses and distortion with hidden line removal.

VASPAT

VASPAT (Reference 4) translates VAST finite element model files into PATRAN format to allow the display of submarine pressure hull geometry with PATRAN. VASPAT will also translate VAST analytical results so that PATRAN postprocessing graphics can be used.

ADINA

VAST is currently limited to linear elastic analysis. A program called ADINA (Automatic Dynamic Incremental Nonlinear Analysis) (Reference 2) has been chosen for nonlinear analysis. This permits the use of nonlinear materials, post buckling analysis, and stress prediction beyond the elastic limit for static and dynamic loads. Through the use of translator programs ADIDAT and ADIPOS, the SUBHUL created VAST files are converted to ADINA format and the ADINA analytical results can be displayed by VASTG.

3.3 Auxiliary Files

These files are used to control the array sizes to keep within the limitations of the computer available. The files are inserted into the program source code by INCLUDE statements (Reference 8).

SUBHUL.PAR

This file controls the program array sizes.

SUBHUL.ICM

This file contains the main program common block.

SUBHUL.DIM

This file contains the main dimension statement.

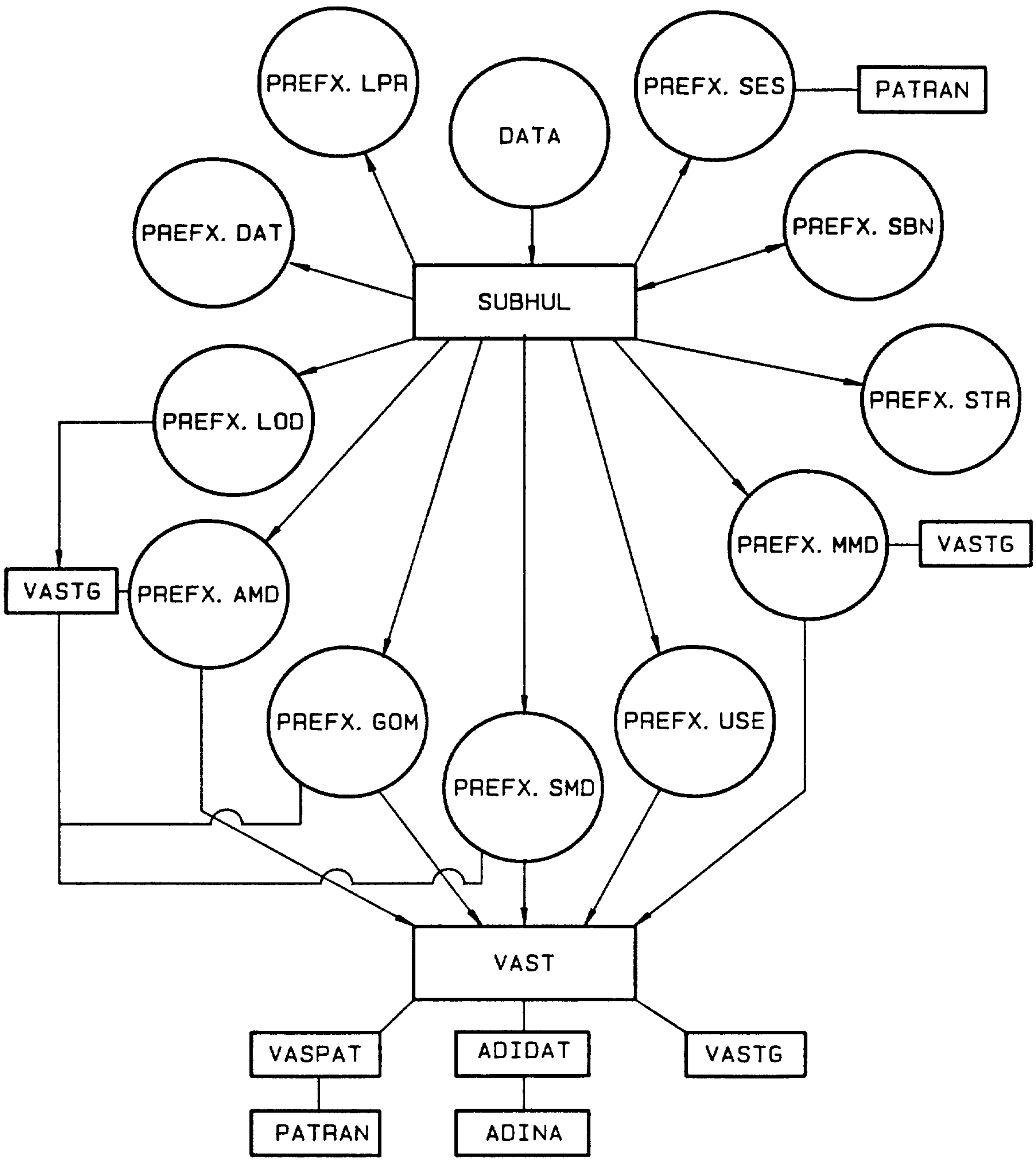


Figure 3.1 Schematic of SUBHUL System

CHAPTER 4

4. MODEL GENERATION

4.1 Basic Data

To create a finite element model of the pressure hull a certain amount of planning is required. This is best accomplished by a rough sketch as shown in Figure 4.1 in which the important dimensions defining the geometry are shown. The axis system for SUBHUL is a right handed XYZ coordinate system with the X axis the length axis for the hull (Figure 4.2). The transition between the forward endcap and the hull has been selected as the forward perpendicular. All X dimensions forward of this point are negative and all X dimensions aft of it are positive.

The diameters and their distances from the forward perpendicular, chosen to describe the hull, should correspond with the location of ring stiffeners and any transitions in plate thickness. The diameters shown in Figure 4.1 locate the endcaps, define the general shape of the hull, the plate thickness, and the larger than normal ring frames. The units to be used for dimensions and loads are input at this time as well as the decision to display a sail or not. The radii of the hemispherical end caps are also specified as part of the basic data. On completion of this phase the data are stored on a permanent file where they can be edited within SUBHUL if required. An example of a basic data file is shown in Appendix A.

At this stage in a design problem it is useful to use a program such as PRHDEF (Reference 9) based on pressure vessel design formulas, to establish the basic dimensions such as shell thickness and ring frame sizes.

4.2 Structural Data

Once the basic data have been established there is a fair amount of flexibility left in defining the structure of the pressure hull.

4.2.1 Pressure Hull Shell

The hull shell is modelled using superparametric thick thin shell elements with 8 mid thickness displacement nodes and sixteen geometric nodes, see Figure 4.3(a). Each displacement node has five degrees of freedom, i.e. three translations u,v and w (in the global X,Y and Z coordinates), and two local rotations, a and b, as shown in Figure 4.3(b). The user must specify the number of circumferential elements, currently set at a maximum of sixteen, and the number of elements between the ring frame stiffeners. Shell thicknesses are specified during the basic data input for the lengths between the diameters in the basic data. The shell element is element type 1 in the VAST element library. An example of an assembled finite element model of a simple pressure hull shell model is shown in Figure 4.4. The same model with hidden line removal is shown in Figure 4.5.

4.2.2 Ring Frames

Ring frames are modelled by a matching isoparametric beam element (Figure 4.6). The element has three displacement nodes and six degrees of freedom per node, i.e. three translations u, v and w (in the global X,Y and Z coordinates, respectively), and three local rotations a, b and y. Reference should be made to the VAST User's Manual, Reference 1, for more detail on the curved beam elements which are element type 7 in the VAST element library.

Most submarine ring frames are T shapes welded to the shell plates (Figure 4.7). Because the curved beam element is rectangular in cross-section its dimensions must be chosen so that its cross-section is equal in area and stiffness to the T shape it represents. SUBHUL provides two options for achieving this equivalency. One option is to define the beam cross-section by its area, moment of inertia,and eccentricity, i.e. the distance of the neutral axis of the T section to the center of the shell plate thickness (Figure 4.7). The second option is to define the T section by specifying the width and thickness of the flange along with depth and thickness of the web. From either of these inputs SUBHUL will calculate the equivalent rectangular cross-section (Figure 4.8). The ring frames will match the shell plates in the circumferential direction using the same node numbers. The frames are located axially at the discretion of the user. Any number of frames can be placed equally spaced between the defined diameters in the basic data and between a defined diameter and a bulkhead in the basic data. Frames of different sizes can be placed at each of the diameters given in the basic data. Frames cannot be placed at bulkhead locations. The frame sizes can also differ for each group of equally spaced frames.

The Ring frames can be examined, as a display of tabular data (Table 4.1) and as graphic display of the frames and half hull outline on completion of input or on restart to generate a VAST file (Figure 4.9). The table can be edited to change individual frame sizes, and the eccentricity of the frames can be changed to place them on the inside or the outside of the pressure hull.

Ring frames can also be displayed when the option to plot the finite element model appears on the screen. In this case they can be plotted as part of the overall structure, or separately by plotting element type 7 (Figure 4.10). It is also possible to display beam node numbers at this time.

4.2.3 Bulkheads

The bulkheads are modelled with eight noded quadrilateral membrane elements or the eight noded shell elements, both of which are degenerated to triangular form. See Figure 4.11 and elements types 1 and 20 in the VAST User's Manual. The bulkhead model is crude, with only one element radially and is used in the model only for pressure hull support. A more refined model with stiffeners would be required to represent accurately a bulkhead that can carry a normal pressure load.

Bulkheads can be displayed with the finite element plotting option, along with the frames (Figure 4.12) or by themselves by requesting element types 1 or 20 to be plotted (Figure 4.11). The node numbering can be displayed at this time if required (Figure 4.13).

4.2.4 Endcaps

The hemispherical endcaps are modelled with the same thick thin shell elements used for the pressure hull. There is no limit on the number of elements that can be specified in axial direction for the endcap except for limitation on the total size of the hull model. Currently, up to sixteen elements can be used in the circumferential direction, although the number can easily be changed by altering the parameter NC in the parameter file SUBHUL.PAR. The first row of circumferential elements in the bow end cap and the last row in the stern end cap can be chosen by the user as either the eight noded quadrilateral shell or its degenerated triangular form. In the quadrilateral form, the element is best suited for use with the fluid element or panel boundary element which cannot be degenerated to triangular form. The degenerated triangular form is best used for stress or in-air vibration analysis. The remaining specifications are the shell thickness and the radius for each cap. The radii cannot be less than the radii of the hull cylinder where they attach.

They may, however be greater than these local hull radii (Figure 4.14). The thickness of the end caps may also be modified from a constant to variable thickness by an option which allows adjustment at the axial node locations.

A graphic display of endcaps is shown in Figure 4.15 as part of the full finite element model and separately in Figure 4.16. An example of the endcap node numbering is shown in Figure 4.17.

4.3 Non Structural Mass

The structural mass of the model is calculated automatically by VAST. Non structural mass or such as engines, fuel and weapons must be supplied by the user if a vibration analysis is to be carried out to predict the the natural frequencies. The masses and their distances from the forward perpendicular are entered to SUBHUL, which distributes each mass amongst the circumferential nodes forming the two frames between which the specified distance falls. If the mass is more localized it may be entered along with the node number to which it is attached.

On completion of the mass data input the mass file created can be displayed on the terminal screen (see Table 4.2). At this time the data can be edited. The mass data can also be plotted by SUBHUL in vector form superimposed on the finite element model (Figure 4.18). They also can be plotted as bar charts and graphs showing the longitudinal and transverse distribution (see Figures 4.19 and 4.20).

4.4 Boundary Conditions

Boundary conditions for the model must be specified before a finite element analysis can be carried out. In SUBHUL they can be defined in two ways. One way is to use preset boundary conditions, and the other is to specify constraints with the screen cursor by calling VASTBC (Reference 2) through SUBHUL. The symbols used for the constraints indication are in vector form as illustrated in Figure 4.21.

There are three types of preset boundary conditions which can be applied to the hull model and there are two types of models to which they can be applied. The types of boundary conditions are a fully constrained positive definite system, a partially constrained system and an unconstrained or free-free system. The partially constrained and free-free systems can only be used for vibration or dynamic response analysis. The fully constrained is best used for static analysis. The model types that are available in SUBHUL are a full model and a half model (Figures 4.22a and 4.22b). For the full model the boundary conditions are applied at the bow endcap as constraints against translations in X,Y, Z and rotation about X, and at the stern endcap against translations in Y and Z. An alternative is constraint against translation in Y and Z at the bow and stern endcaps and against X at the maximum diameter with constraint against X rotation at the bow. These constraints are used when a uniform pressure load is to be applied to the hull. They are shown in graphic form in Figures 4.23a and 4.23b through the use of the plotting option available in SUBHUL. For vibration analysis with the full model the free-free option is the best. In this case it is important to realize that the first six vibration modes predicted by VAST will be rigid body modes. When the half model option is chosen SUBHUL will apply translational constraints in Z, and rotational constraints about X and Y around the outer edges of the model, and X and Y translational constraints will be added at the forward and aft endcaps. A partially constrained model is obtained by not applying the additional constraints at the end caps. The option to apply boundary conditions with the screen cursor gives the user an opportunity to apply other than the preset systems should they not be suitable for the desired analysis. This use of the cursor for boundary conditions is made by a call from SUBHUL to the auxiliary program VASTBC. The user manual for VASTBC is found in Appendix C.

4.5 Loading

The model can be loaded for a static analysis to obtain pressure hull stresses and as the first step in a buckling analysis. Loads can be applied as concentrated nodal loads by specifying the node number and the load value. Loading in the form of hydrostatic pressure is applied by specifying the depth of water over the submarine axis. Although loading of the finite element model by SUBHUL is limited to static loads, the model can be subjected to much more complex loading such as dynamic response, frequency response and response spectrum analysis by the use of other programs such as VASGEN and PATRAN.

4.6 Added Fluid Mass

To predict the natural frequencies of vibration of the submerged submarine structure the effect of the surrounding water must be taken into account. There are two options in SUBHUL for modelling the surrounding water. One is the fluid element method which generates an interface of four noded quadrilateral elements (Figure 4.25) whose nodes are connected to the corner nodes of the hull shell elements. The interface elements are also connected to the first layer of eight noded fluid elements (Figure 4.26). Up to five layers can be added to the outer surface of the hull. In most cases three layers are sufficient. The layers are proportioned by SUBHUL into one, three, five, seven and nine times the maximum radius of the hull (Figure 4.27).

The second option is the panel method, described in Reference 5. It is much more efficient in generating the added fluid mass matrix as it uses a distribution of matching panels whose singularities represent the velocity potential in the surrounding fluid. The fluid added mass matrix is calculated by relating the pressure field in the fluid to the structure surface accelerations. The panels are shown in Figure 4.28.

4.7 Sail Model

The sail model is used for visualization purposes only, as it is mostly fairing. It uses the shell element to show the sail form. The NACA 0020 section was chosen arbitrarily. An example of a hull model with sail is shown in Figure 4.29.

4.8 Program Model Size Control

The maximum size of the model generated by SUBHUL is controlled basically by two parameters which are the number of longitudinal elements and the number of circumferential elements. Control is through a parameter file SUBHUL.PAR in which NL is the number of longitudinal elements and NC is the number of circumferential elements. The maximum model size can be adjusted with these two parameters, as all the others in the program except the number of bulkheads, the number of sail elements and the number of input diameters, are automatically set. A print out of SUBHUL.PAR is shown for reference. After file SUBHUL.PAR has been changed, the source file SUBHUL.FOR must be recompiled and linked.

```
      PARAMETER (NL=100,NC=16,MNBLK=15,MND=20,NSAIL=1000,
     #NNL=NL*2+1,NNC=NC*3+2,NBC=MNBLK*NC*8,NIBEL=MND+MNBLK-1,
     #MNT=NL*NC*8,NBD=MND+MNBLK,MBCN=MNBLK*5,MXBT=MNBLK*NC,
     #MXNN=(NL+1)*(NC*2+1)+(NL*NC+1)+((NC+1)*MNBLK),MXBC=(NL+1)*NC*3)
C     NL NUMBER OF LONGITUDINAL ELEMENTS
C     NC NUMBER OF CIRCUMFERENTIAL ELEMENTS
C     MND MAXIMUM NUMBER OF INPUT DIAMETERS
C     NNL NUMBER OF LONGITUDINAL NODES
C     NNC NUMBER OF CIRCUMFERENTIAL NODES
C     MNBLK MAXIMUM OF BULKHEADS
```

C NBC NUMBER OF BULKHEAD CONNECTIVITY NODES
C MNT MAXIMUM NUMBER OF THICKNESSES AT ELEMENT NODES
C NBD NUMBER OF BEAM LOCATIONS
C MXNN MAXIMUM NUMBER OF NODES
C MXCB CIRCULAR BEAM NODES
C NSAIL NUMBER OF NODES IN SAIL

13

Table 4.1 Ring Frame (Stiffeners) Location and Size

NO	X DISTANCE	WIDTH	DEPTH	ECCENTRICITY
1	0.000	0.478	11.767	-7.229
2	51.750	0.532	10.580	-7.375
3	103.500	0.532	10.580	-7.375
4	155.250	0.532	10.580	-7.375
5	207.000	0.492	17.540	-10.674
6	348.857	0.532	10.580	-7.375
7	490.714	0.532	10.580	-7.375
8	632.571	0.532	10.580	-7.375
9	774.429	0.532	10.580	-7.375
10	916.286	0.532	10.580	-7.375
11	1058.143	0.532	10.580	-7.375
12	1355.625	0.532	10.580	-7.375
13	1511.250	0.532	10.580	-7.375
14	1666.875	0.532	10.580	-7.375
15	1822.500	0.532	10.580	-7.375
16	1978.125	0.532	10.580	-7.375
17	2133.750	0.532	10.580	-7.375
18	2289.375	0.532	10.580	-7.375
19	2445.000	0.492	17.540	-10.674
20	2551.250	0.532	10.580	-7.375
21	2657.500	0.532	10.580	-7.375
22	2763.750	0.532	10.580	-7.375
23	2870.000	0.516	9.447	-6.111

Table 4.2 Non Structural Mass Data

LUMPED MASSES

	NODE	X	Y	Z	MX	MY	MZ
1	217	83.33	83.33	83.33	0.00	0.00	0.00
2	218	83.33	83.33	83.33	0.00	0.00	0.00
3	219	83.33	83.33	83.33	0.00	0.00	0.00
4	220	83.33	83.33	83.33	0.00	0.00	0.00
5	221	83.33	83.33	83.33	0.00	0.00	0.00
6	222	83.33	83.33	83.33	0.00	0.00	0.00
7	223	83.33	83.33	83.33	0.00	0.00	0.00
8	224	83.33	83.33	83.33	0.00	0.00	0.00
9	225	83.33	83.33	83.33	0.00	0.00	0.00
10	226	83.33	83.33	83.33	0.00	0.00	0.00
11	227	83.33	83.33	83.33	0.00	0.00	0.00
12	228	83.33	83.33	83.33	0.00	0.00	0.00
13	343	166.67	166.67	166.67	0.00	0.00	0.00
14	344	166.67	166.67	166.67	0.00	0.00	0.00
15	345	166.67	166.67	166.67	0.00	0.00	0.00
16	346	166.67	166.67	166.67	0.00	0.00	0.00
17	347	166.67	166.67	166.67	0.00	0.00	0.00
18	348	166.67	166.67	166.67	0.00	0.00	0.00
19	349	166.67	166.67	166.67	0.00	0.00	0.00
20	350	166.67	166.67	166.67	0.00	0.00	0.00
21	351	166.67	166.67	166.67	0.00	0.00	0.00

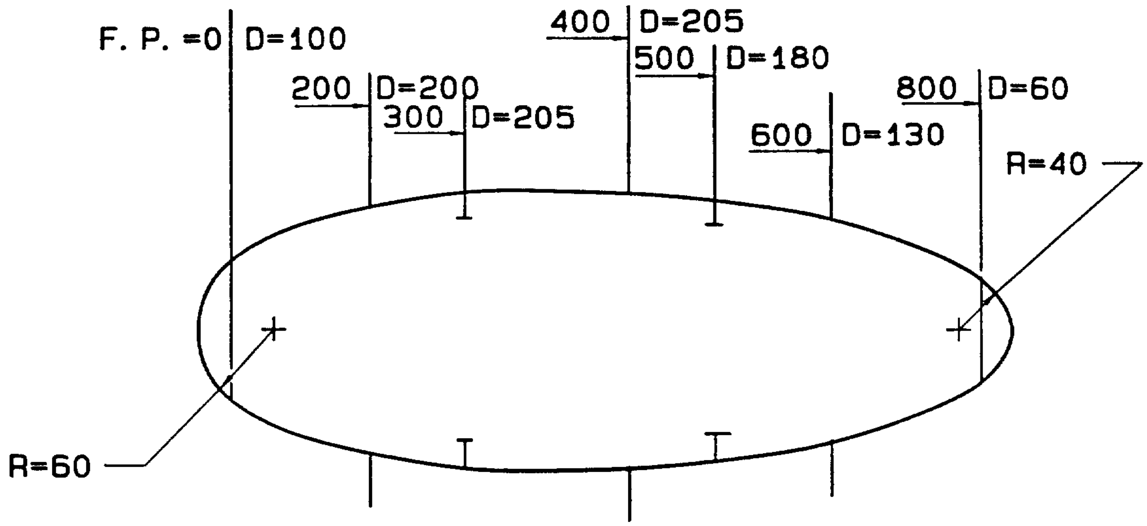


Figure 4.1 Basic Data

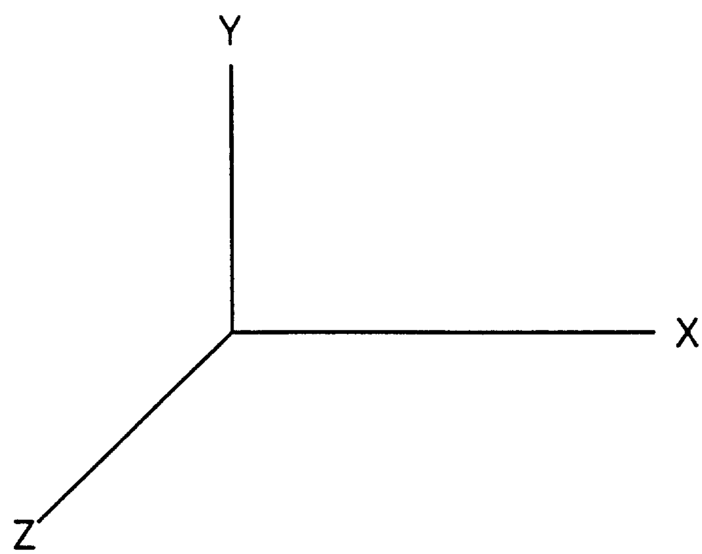


Figure 4.2 SUBHUL Coordinate System

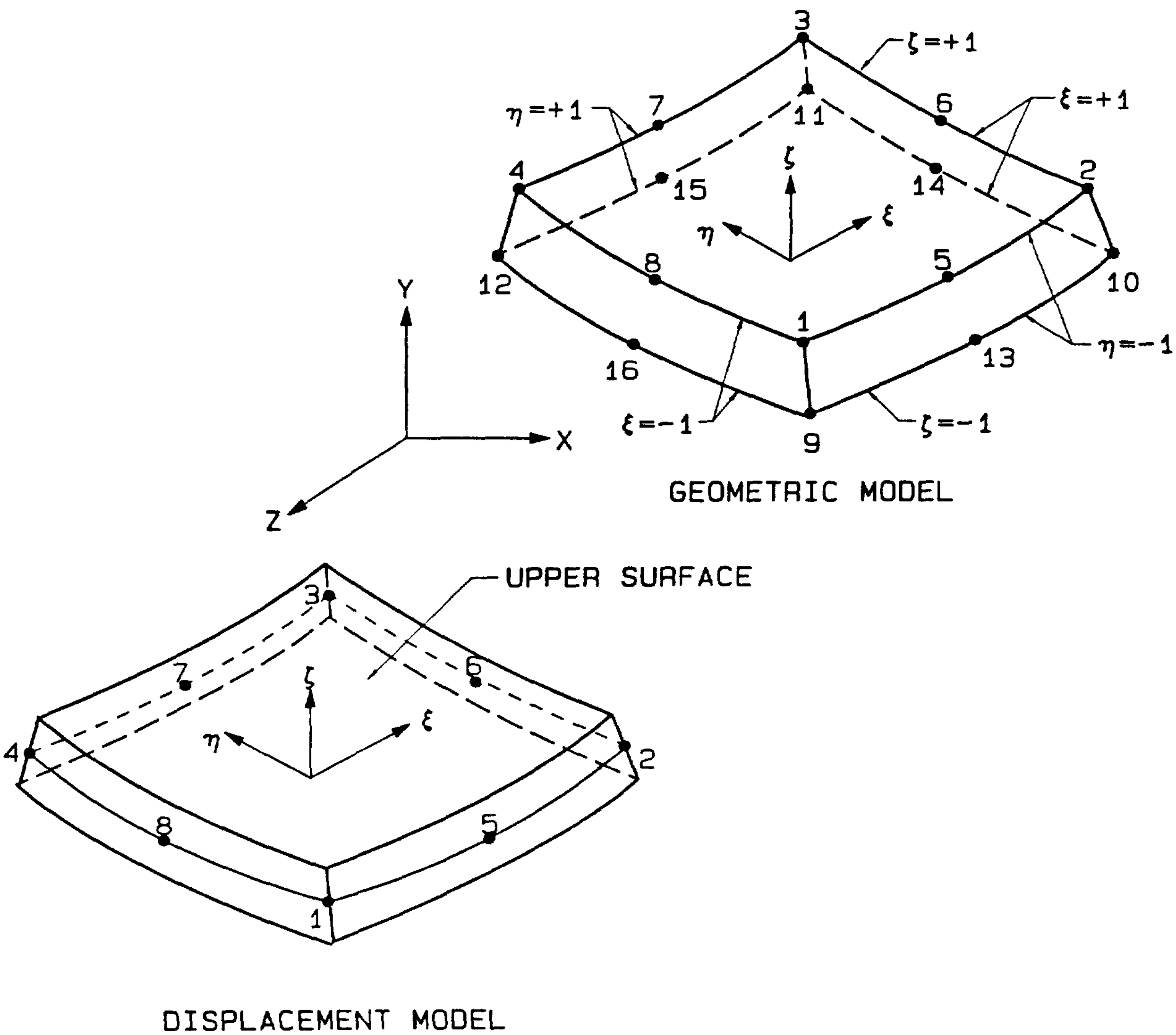


Figure 4.3a Pressure Hull Shell Element

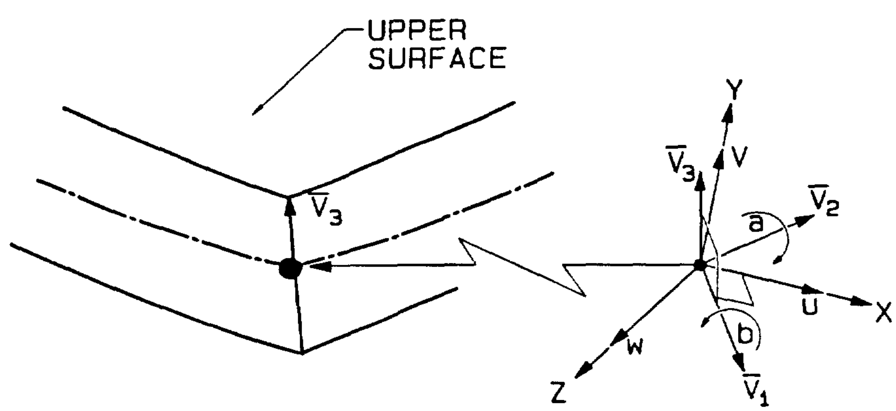


Figure 4.3b Pressure Hull Element Degrees of Freedom

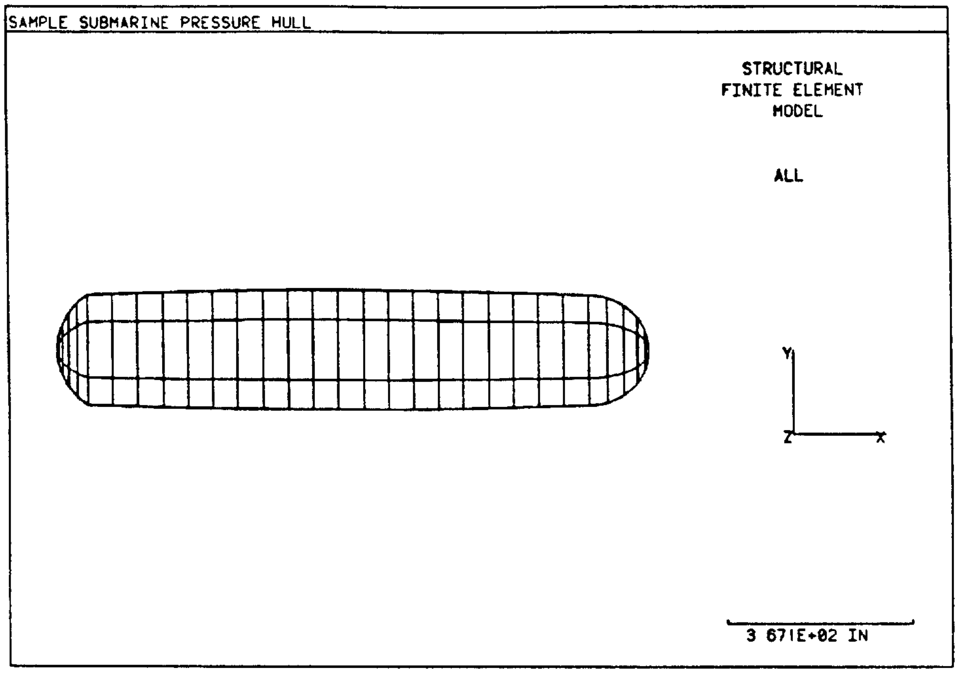


Figure 4.4 Finite Element Model of a Simple Pressure Hull

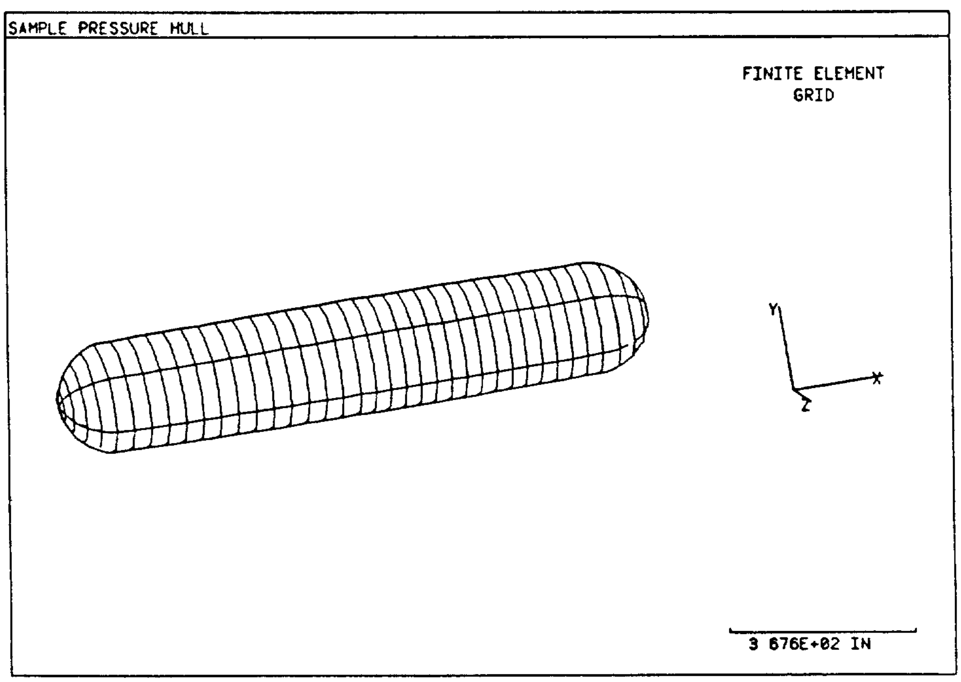
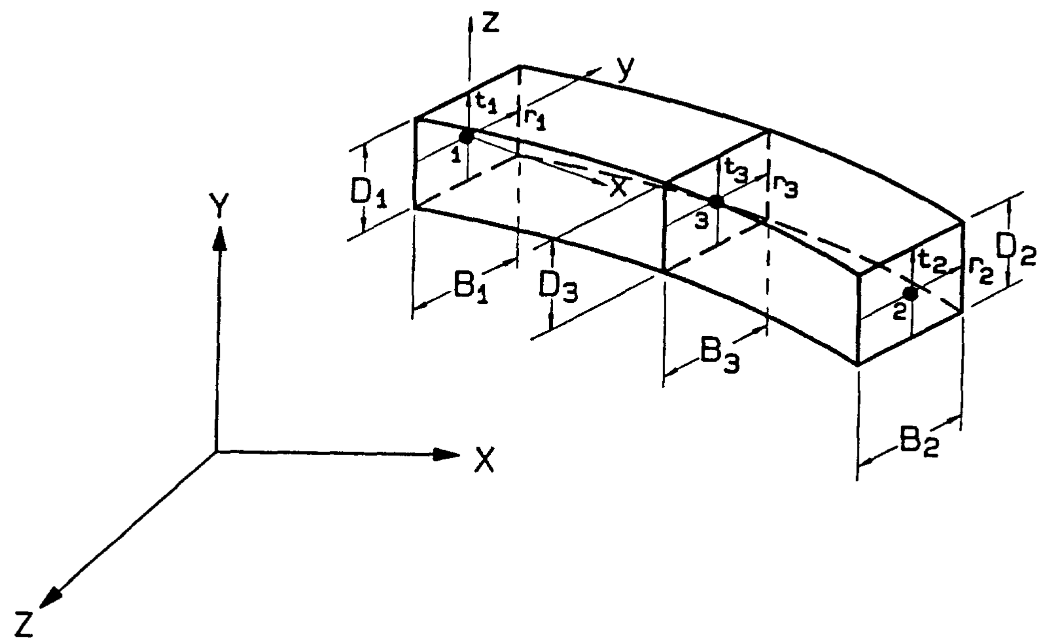


Figure 4.5 Finite Element Model Plot with Hidden Line Removal



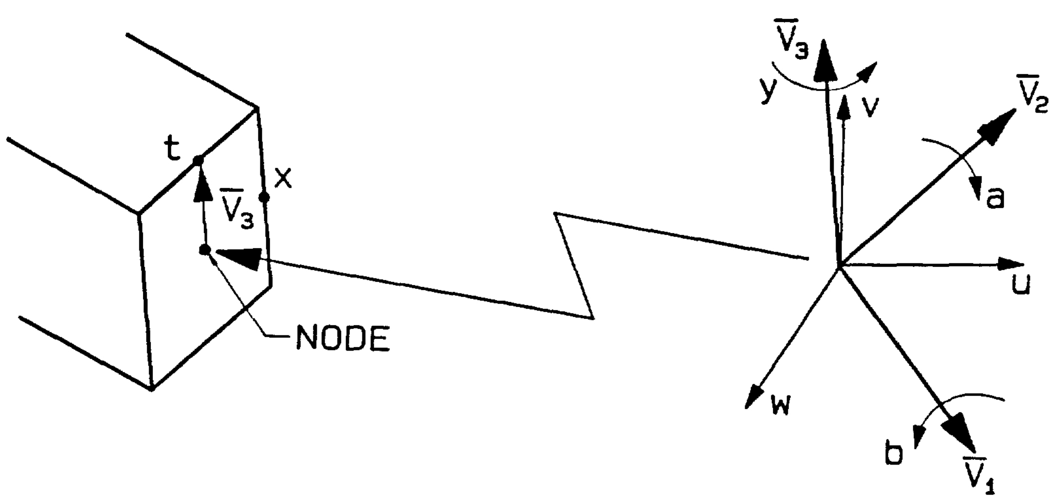


Figure 4.6 Ring Frame Curved Beam Element

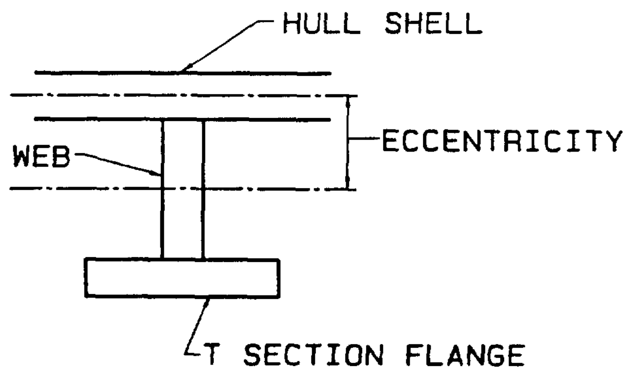


Figure 4.7 T Beam Welded to Hull Shell

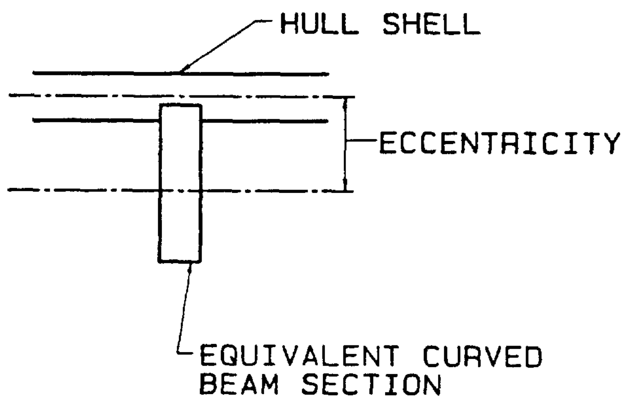


Figure 4.8 Equivalent Curved Beam Rectangular Cross-section

Figure 4.9 Ring Frame Location on Half Hull Outline

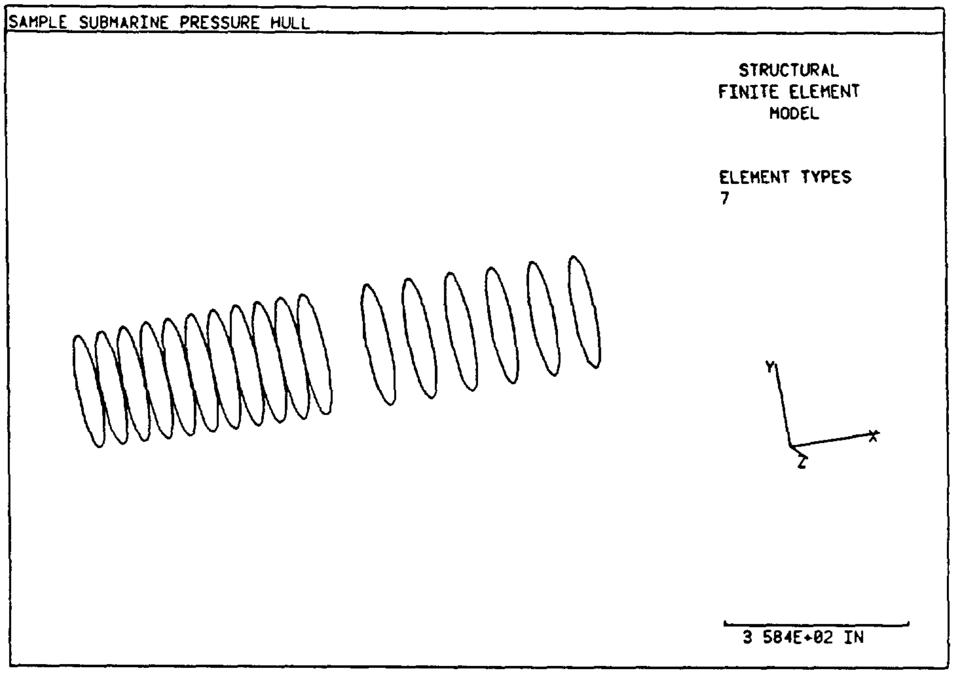


Figure 4.10 Display of Pressure Hull Ring Frames

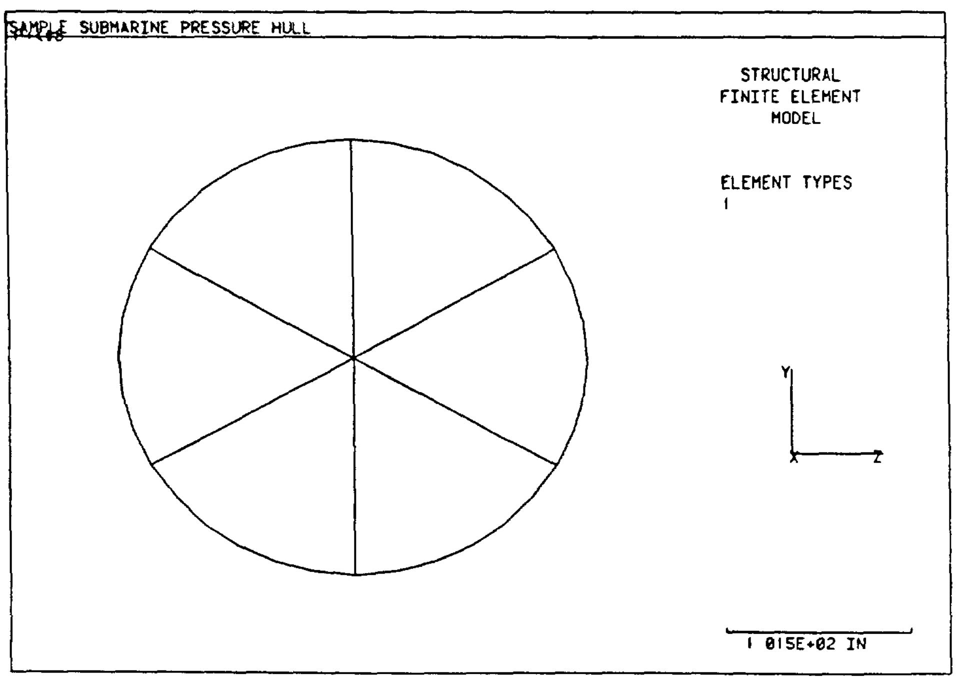


Figure 4.11 Finite Element Model of a Bulkhead

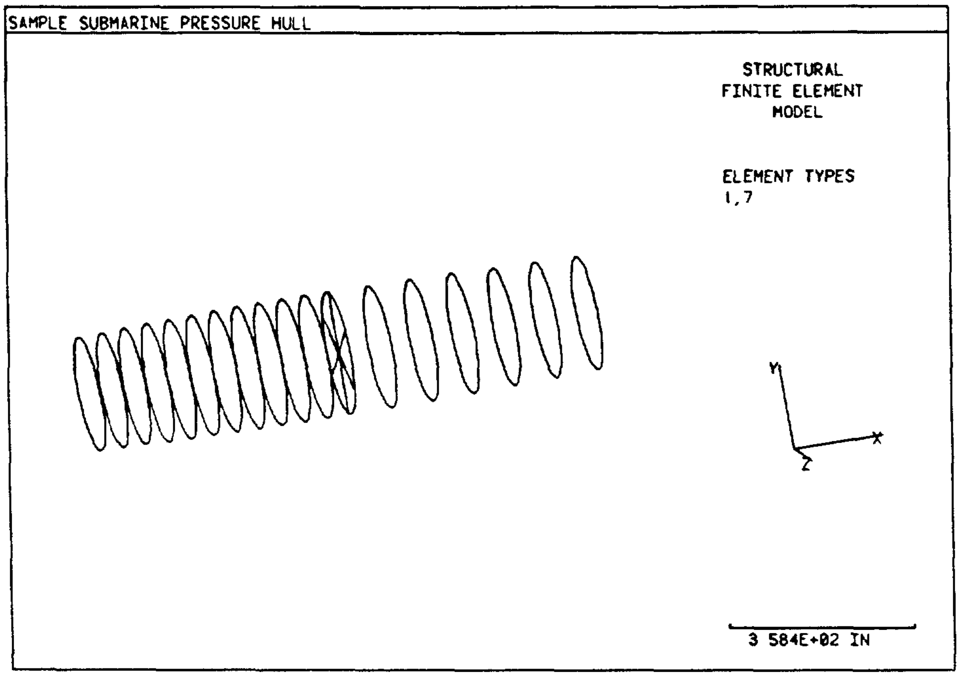


Figure 4.12 Display of Bulkhead Elements Along with Ring Frames

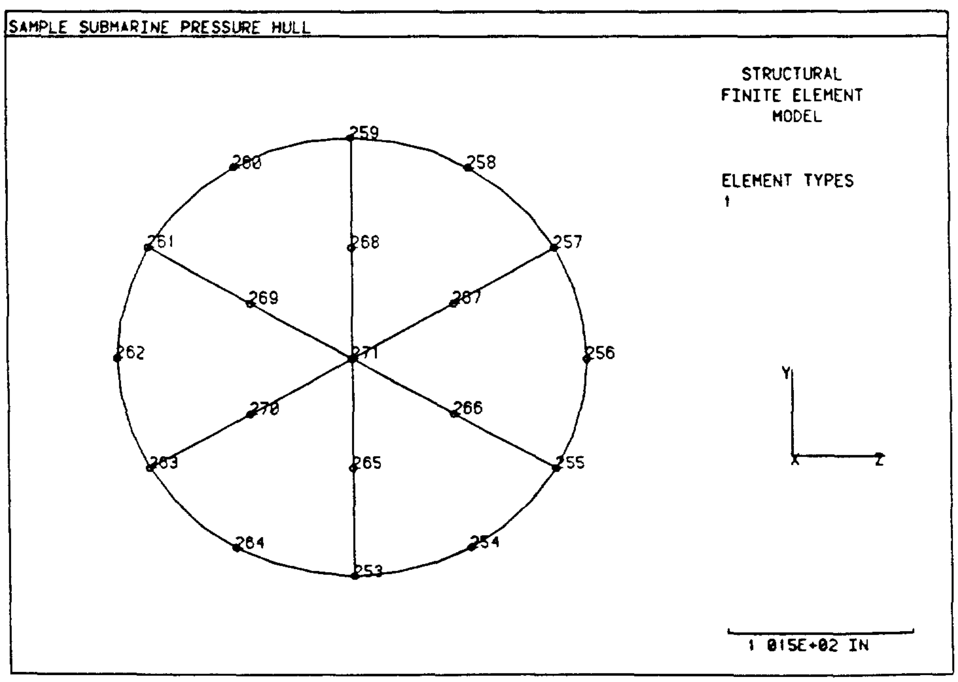


Figure 4.13 Node Numbering of Bulkhead Finite Element Model

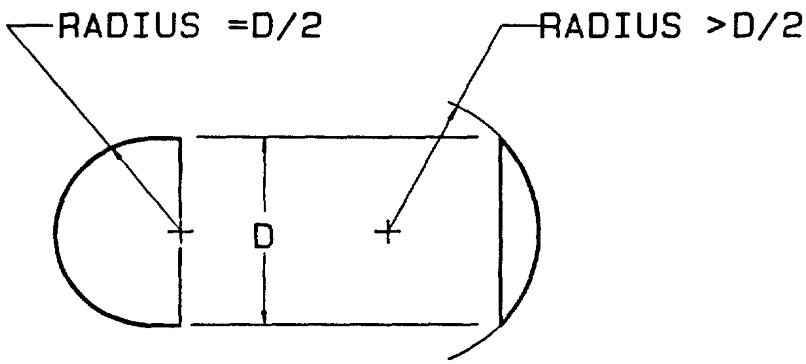


Figure 4.14 Radius of End Caps (Must be Equal or Greater than Hull Radius)

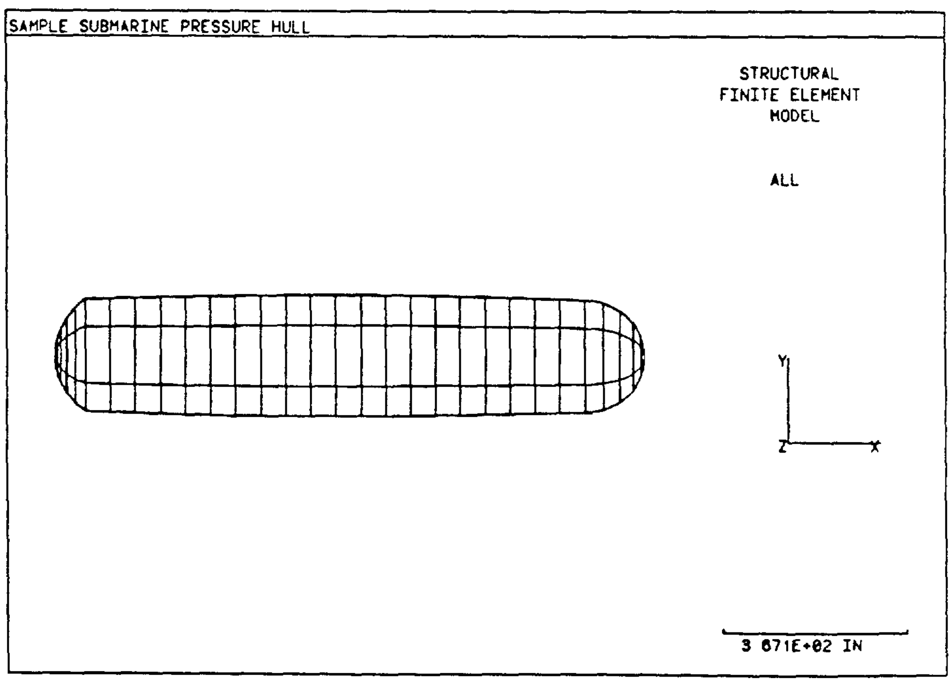


Figure 4.15 Endcaps as Part of the Full Finite Element Pressure Hull Model

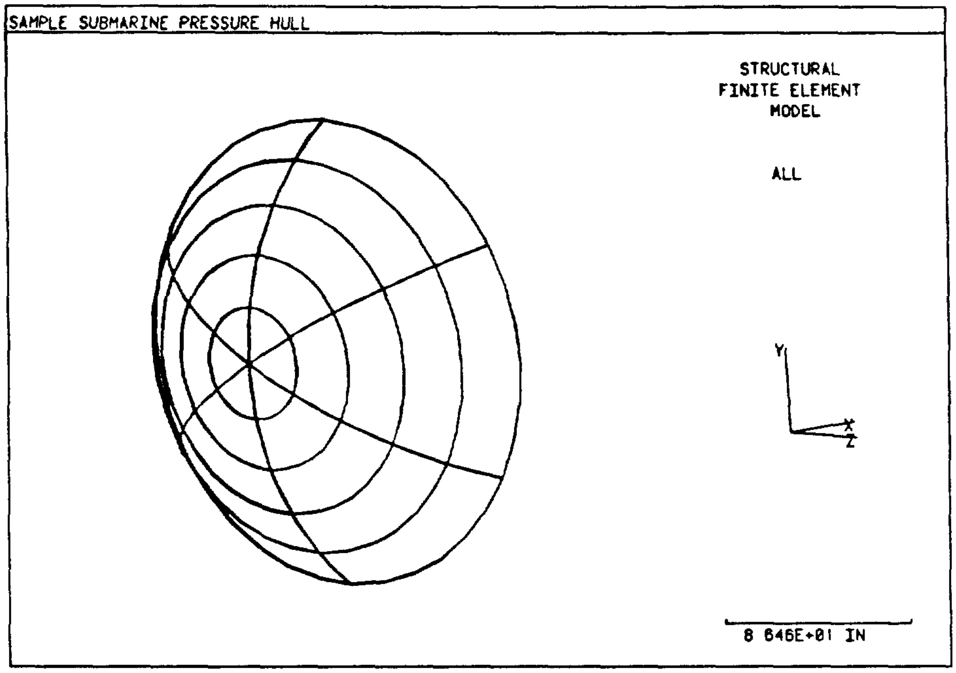


Figure 4.16 Bow Endcap Model Displayed Separately

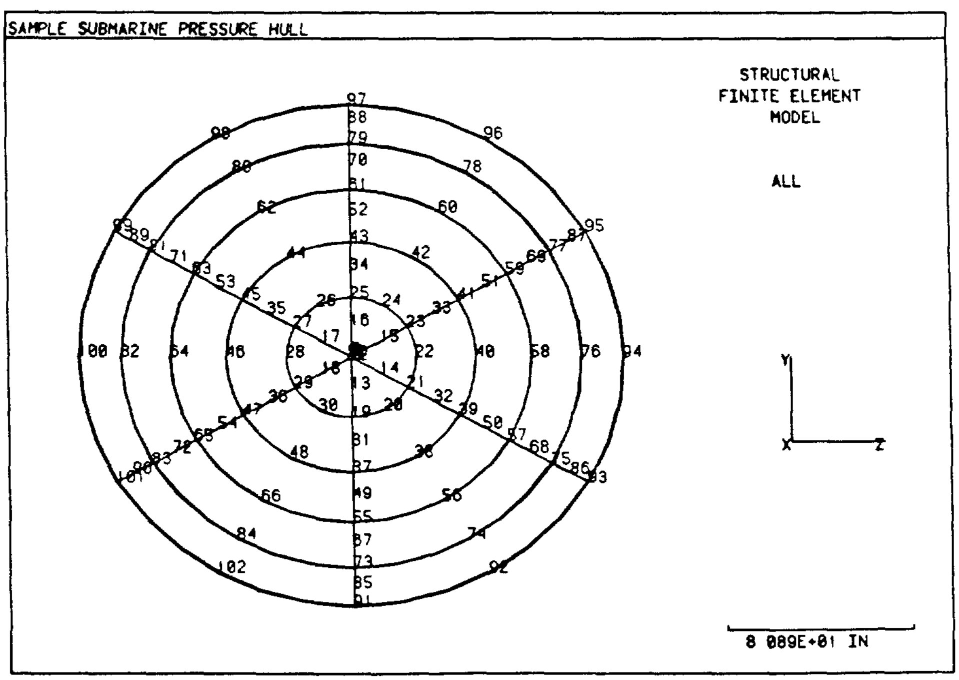


Figure 4.17 Bow Endcap Node Numbering

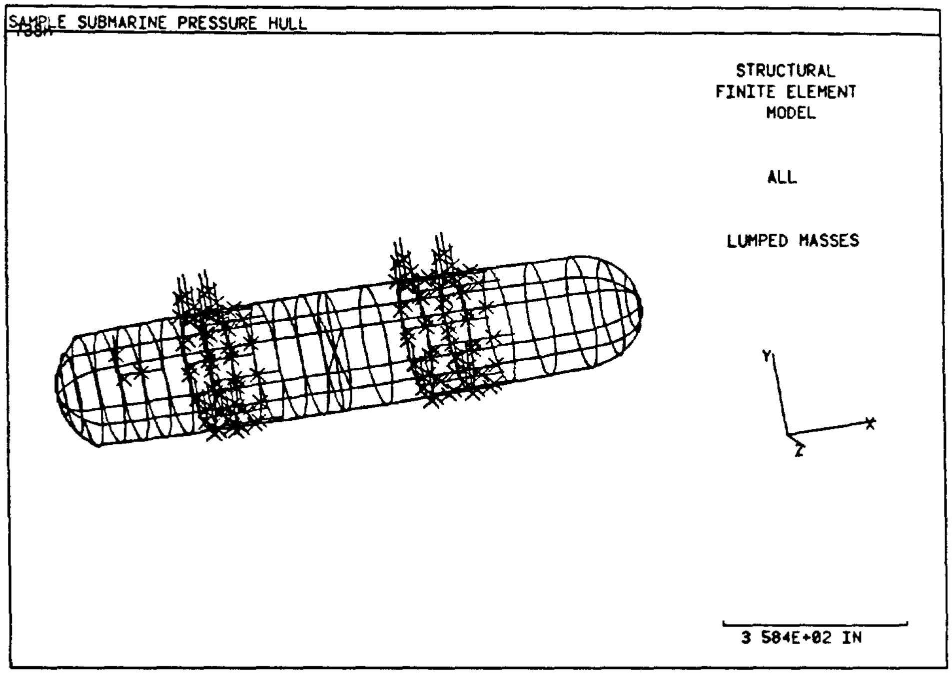


Figure 4.18 Non Structural Mass Locations

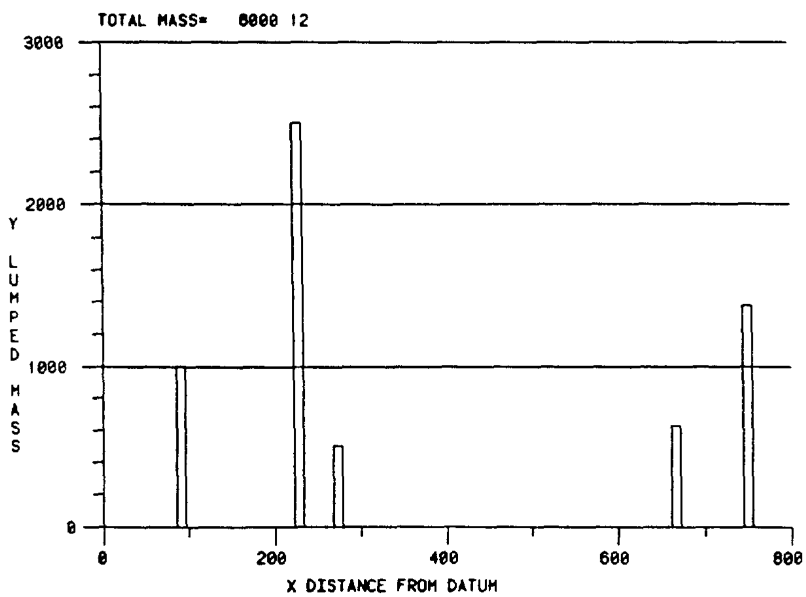


Figure 4.19 Longitudinal Locations of Non Structural Mass

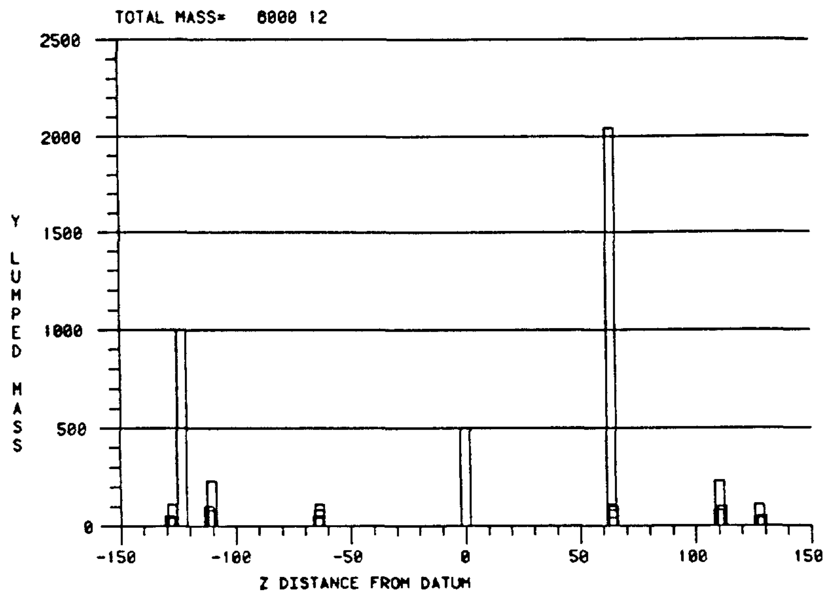


Figure 4.20 Transverse Locations of Non Structural Mass

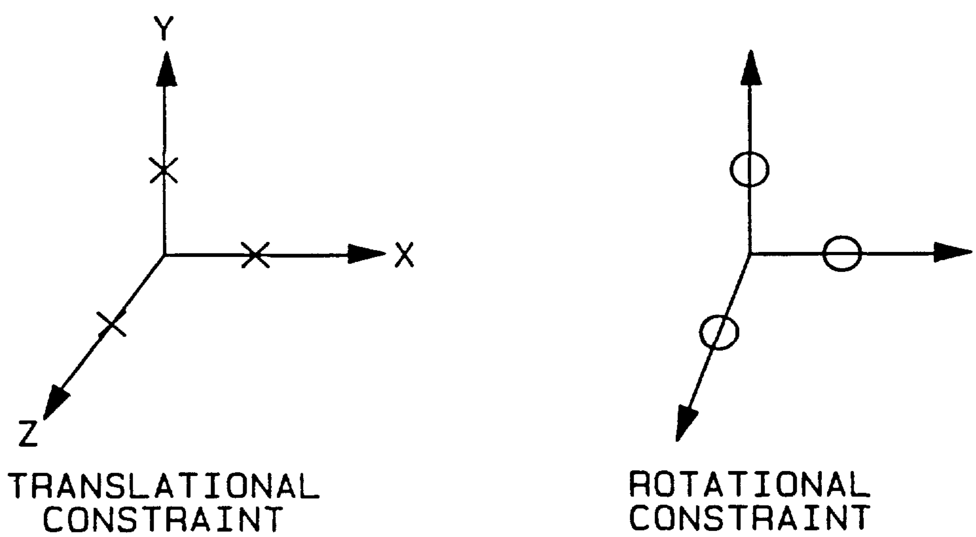


Figure 4.21 Boundary Constraint Symbols

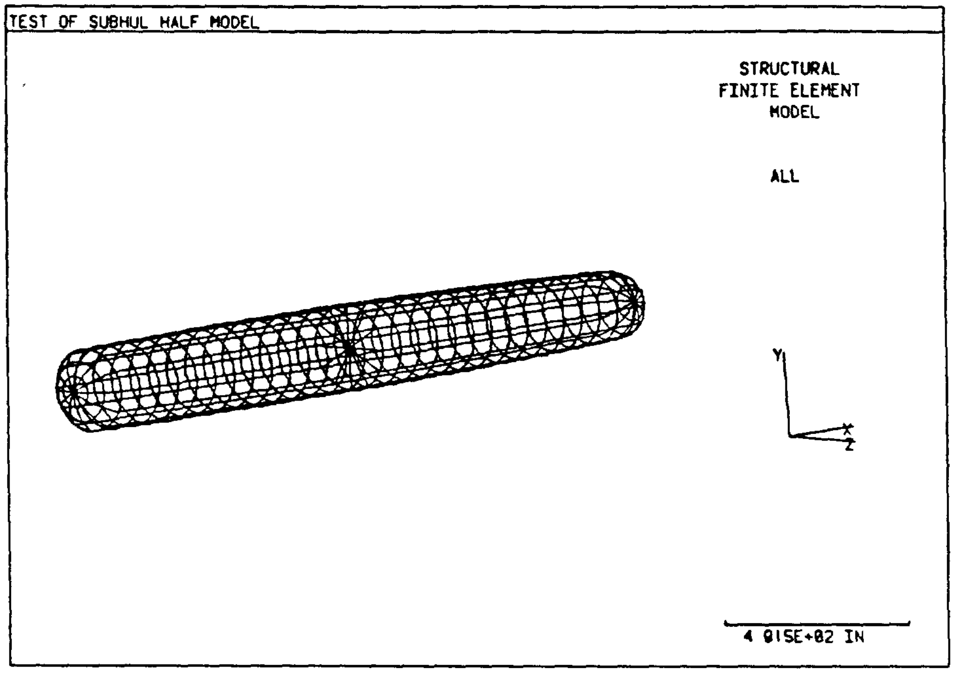


Figure 4.22a Full Hull Finite Element Model

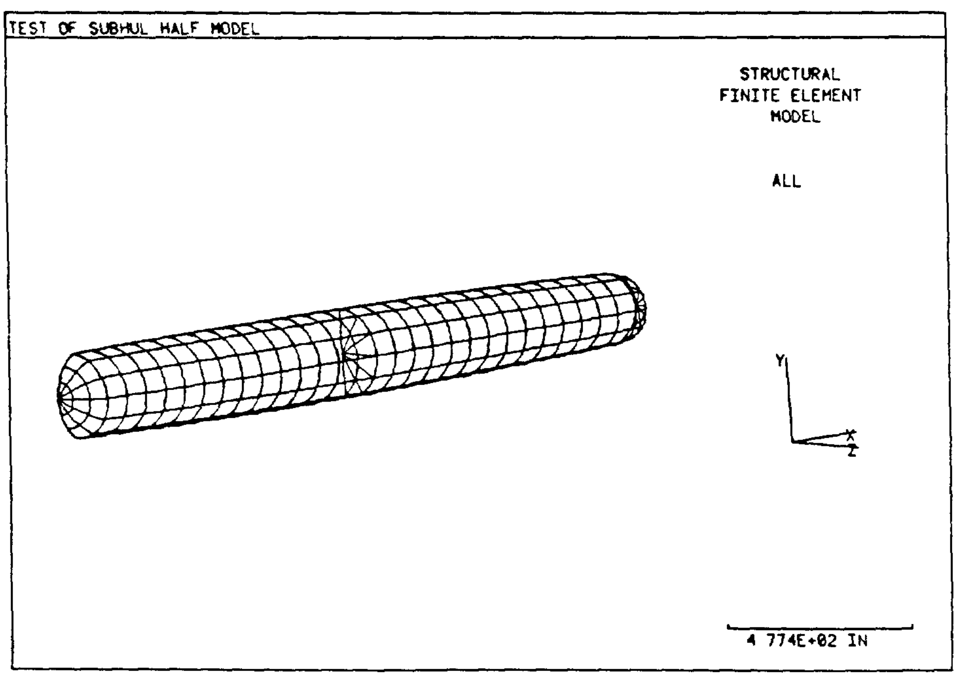


Figure 4.22b Half Hull Finite Element Model

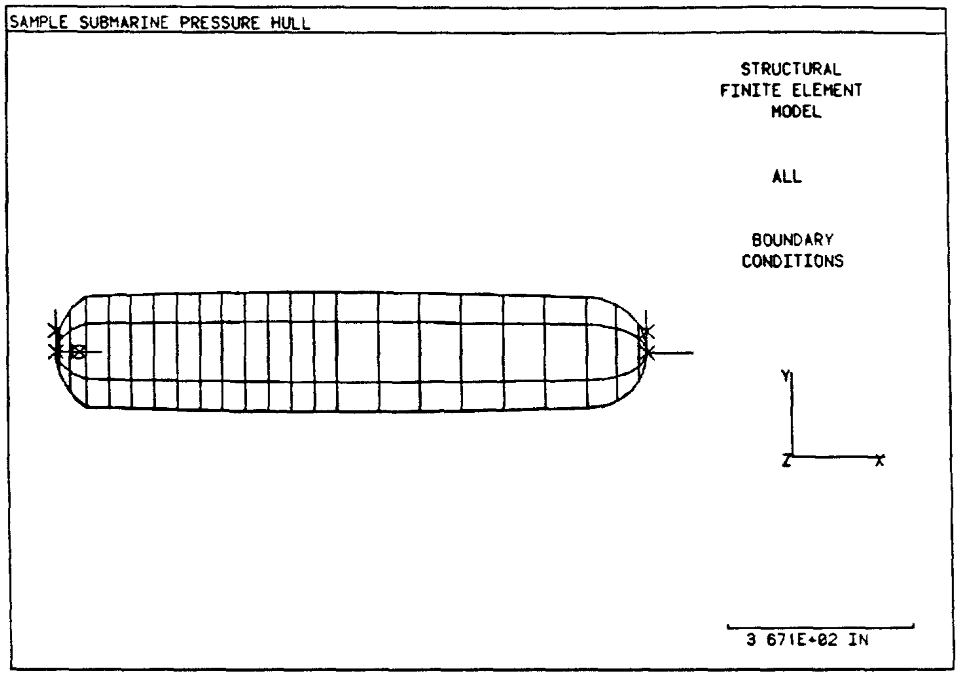


Figure 4.23a Positive Definite Boundary Conditions with Endcap Constraints

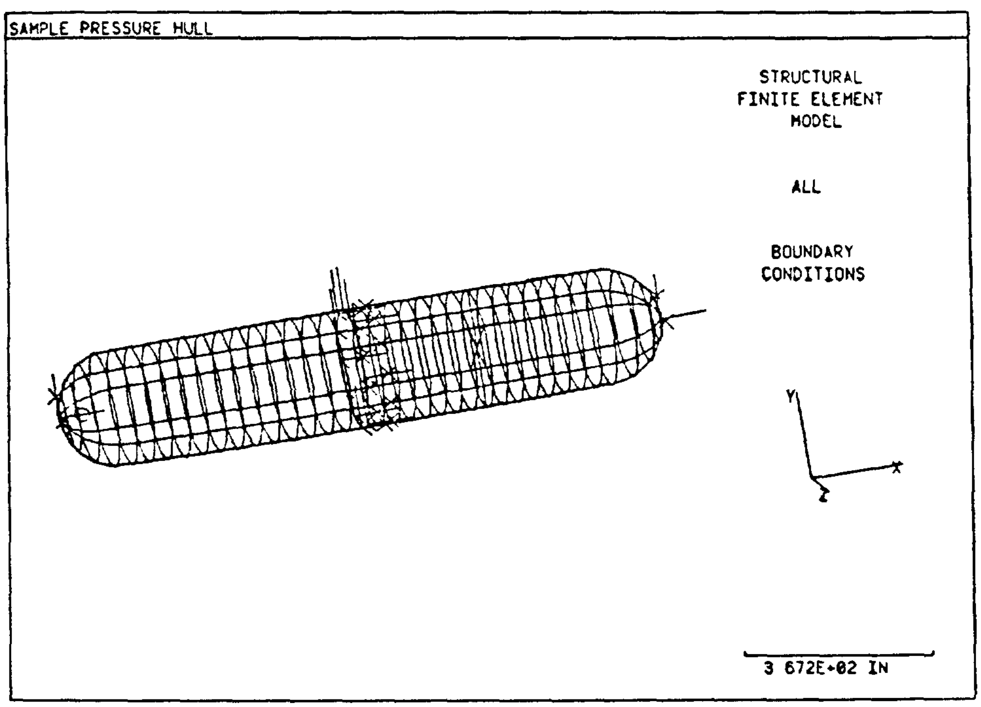


Figure 4.23b Positive Definite Boundary Conditions with Endcap and X Constraints at Maximum Diameter

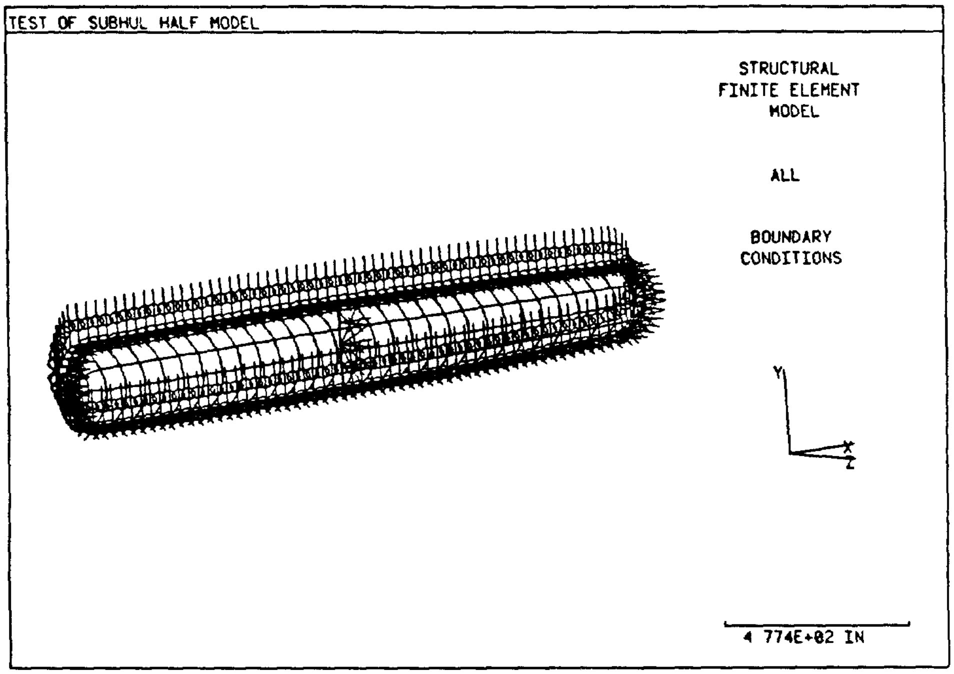


Figure 4.24 Half Model Boundary Constraints

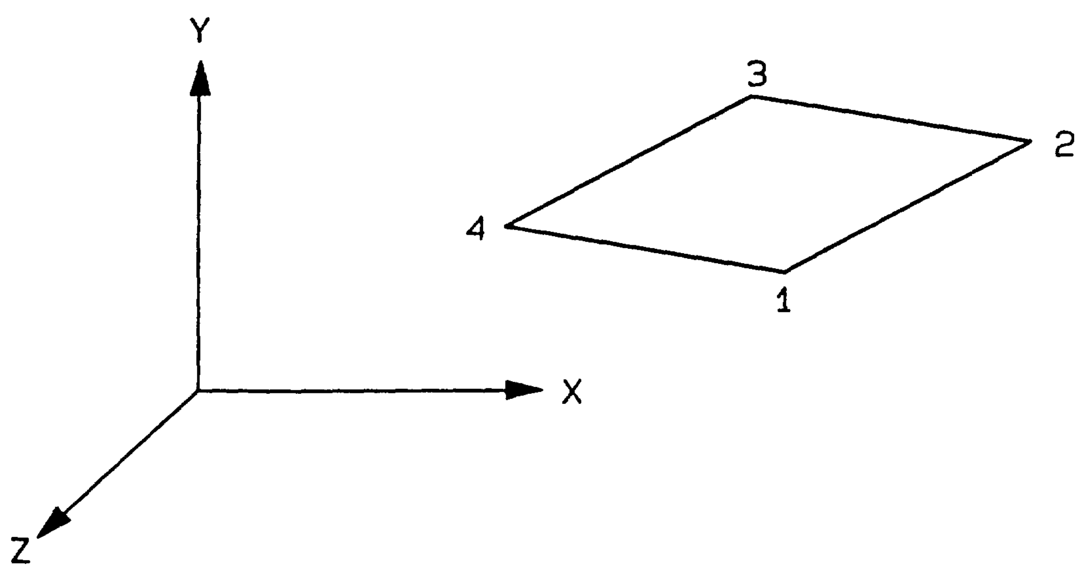


Figure 4.25 4 Node Interface Element

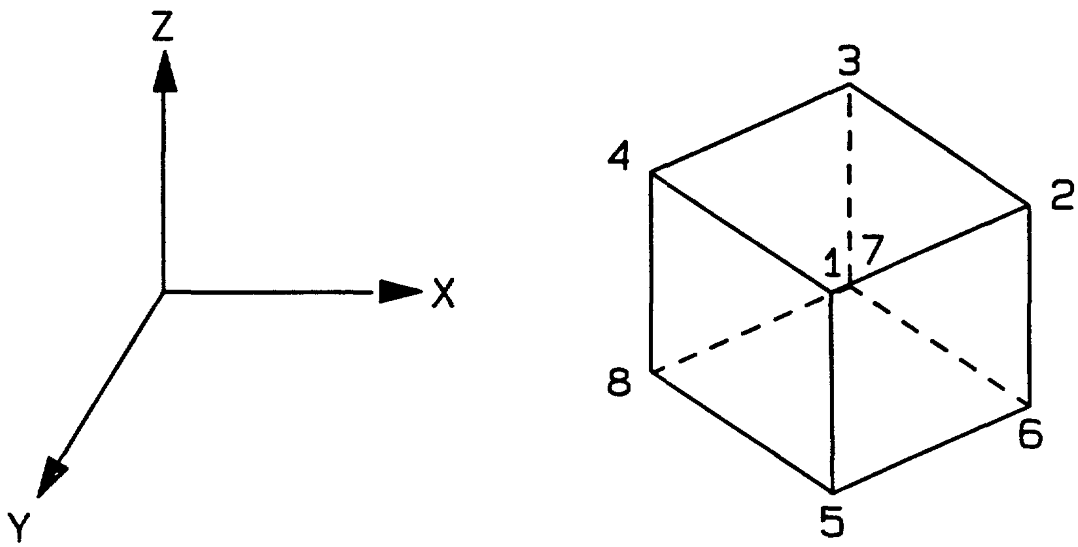


Figure 4.26 8 Node Fluid Element

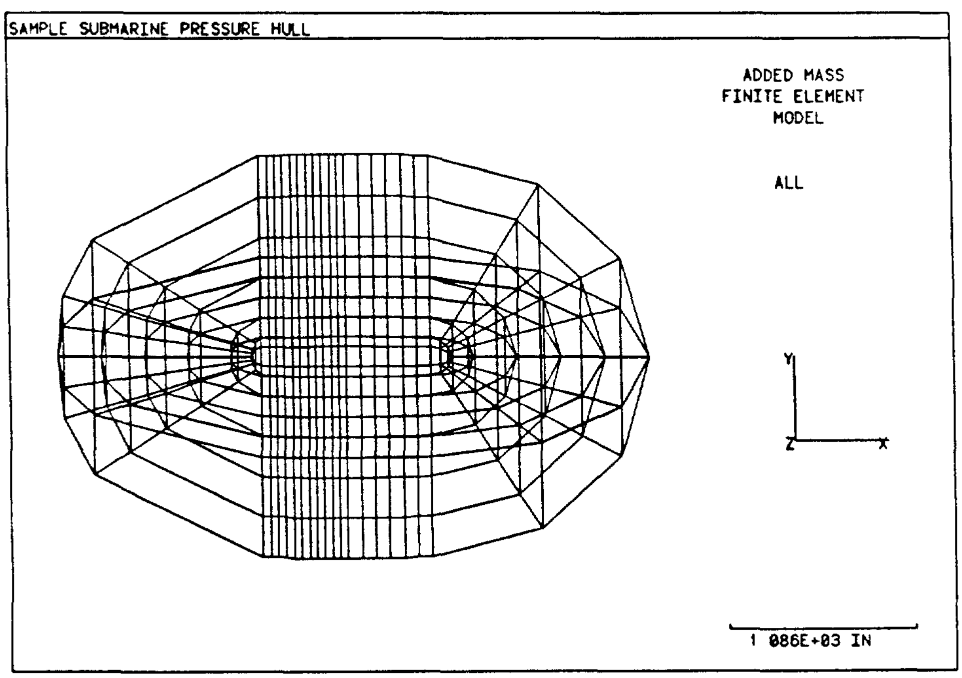


Figure 4.27 Added Mass Fluid Element Model

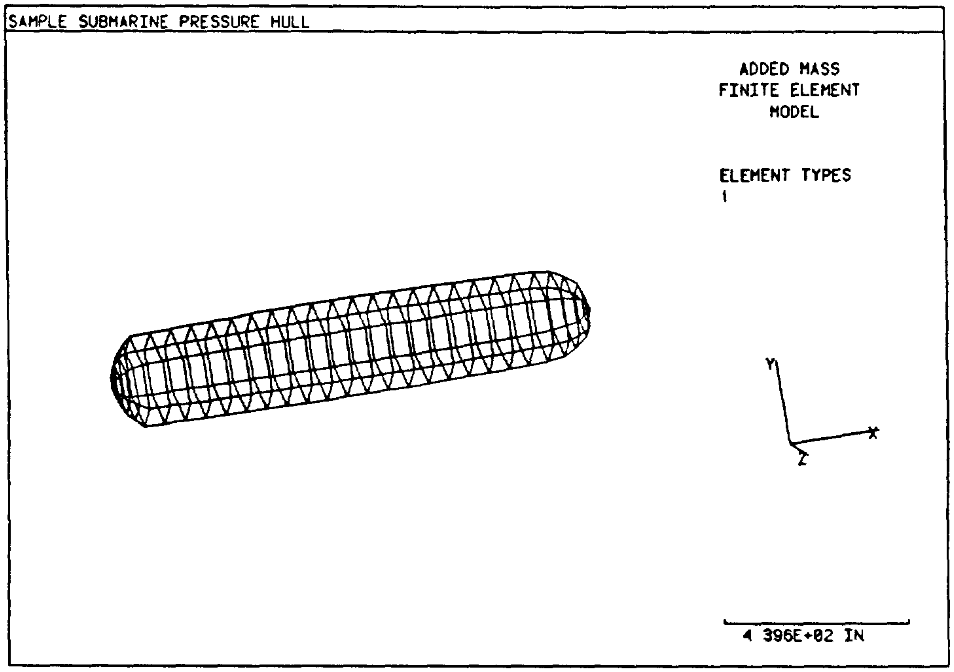


Figure 4.28 Added Mass Boundary Element Panel Model

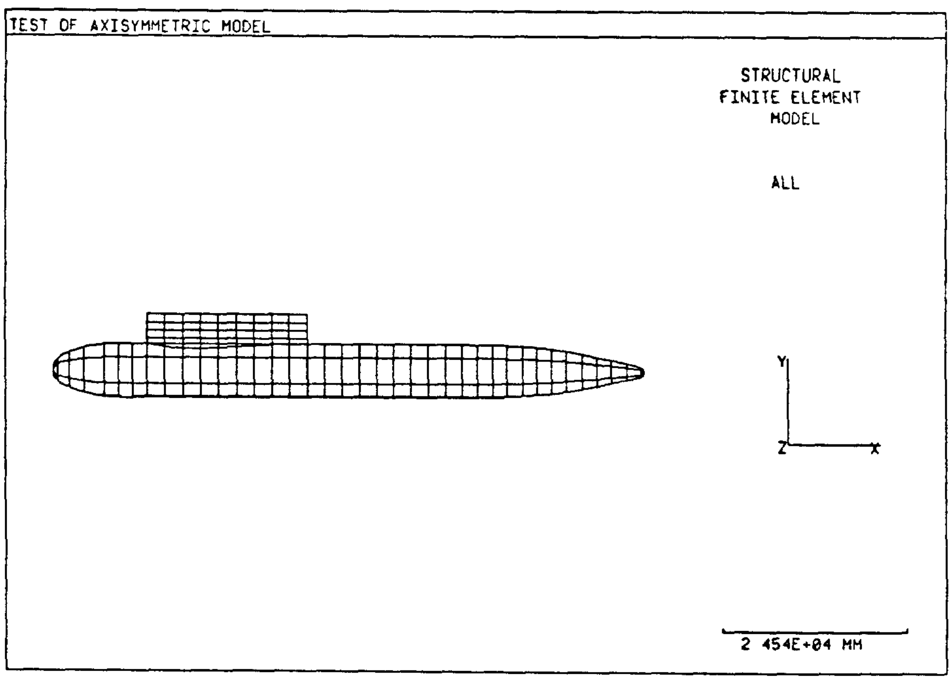


Figure 4.29 Hull Model with Sail

CHAPTER 5

5. DATA INPUT

5.1 Basic Data Input

SUBHUL is an interactive program which prompts the user for the required input through displays on a terminal screen. Before attempting to run the program the user should check for the existence of the executable version of the program in the form of file SUBHUL.EXE. If it does not exist it can be generated by using the information found in Chapter 9. The program assumes the use of a Tektronix 4010/14 terminal or its equivalent and Tektronix PLOT10 software.

To start type

RUN SUBHUL

This results in the following prompt

INPUT A FIVE CHARACTER DATA FILE NAME

A five character data file name (PREFX) is then entered. The program checks for the existence of the basic data file PREFX.DAT. The five character name will form the prefix of all files created by SUBHUL and VAST. After the name is entered the following prompt appears.

NEW FILE NAME
TO CONTINUE = 0
TO CHANGE NAME = 1

This allows the user to change the name should there be an existing file with the chosen name. The entry of 0 results in the following prompt.

SAIL TO BE INCLUDED
YES = 0
NO = 1

A sail may be included for visualization purposes; however, it cannot be used in the structural analysis. A 0 entry results in the following prompt.

SAIL IS NOT INCLUDED WITH PRESSURE HULL
ENTER 0 TO CONTINUE
1 TO CHANGE

If continue is chosen the following prompt appears.

ENTER UP TO 90 CHARACTER TITLE

The title is printed on the VAST input file and appears on the plots of the model including mass and boundry plots. The option to change the title appears next.

ENTER 0 TO CONTINUE
1 TO CHANGE

Units for the model and the analysis are defined next.

ENTER UNITS FOR DIMENSIONS
0 = NIL
1 = IN.
2 = FT.
3 = MM.
4 = M.

Metric units or Imperial units can be chosen.

ENTER UNITS OF FORCE
0 = NIL
1 = LBS.
2 = KIPS.
3 = N.
4 = KN.
5 = MN.

The units of length and force must remain consistent throughout the data input. The program will echo the units chosen.

UNITS CHOSEN FOR DIMENSION = IN. AND LBS
CORRECT YES=0 NO=1

SUBHUL provides three basic modelling options which appear in the next prompt.

CHOOSE PRESSURE HULL FORM
CONVENTIONAL FLAT DECK FORM ENTER 0
AXISYMMETRIC FORM ENTER 1
STEPPED AXISYMMETRIC HULL FORM ENTER 2

The hull forms are described in more detail in Chapter 2. The next prompt is independent of the model and is part of the basic data describing the hull geometry.

ENTER THE NO OF DIA. REQUIRED TO DESCRIBE PRESS HULL

These diameters and their distances from the forward perpendicular are based on factors such as the location of large frames, beam spacing, hull shape, plate thicknesses etc., as described in Chapter 4 under basic data.

ENTER THE DIAMETERS STARTING AT THE BOW

The program prompts for each of the diameters in sequence from the forward perpendicular the first being distance 0.

ENTER DIAMETER LOCATIONS AS DIST FROM FWD PERP

After the last entry of the distances from the bow the diameters and distances will be displayed to correct any input errors.

DIAMETERS AND DISTANCES CHOSEN

```
1   240.00     0.00
2   260.00   500.00
3   240.00  1000.00
IS THERE AN ERROR IN DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
```

If the data are correct, or after they have been edited, the program prompts for plate thicknesses between adjacent diameters.

```
ENTER 2 PLATE THICKNESSES ONE FOR EACH TWO DIAMETERS
```

For example

```
BETWEEN DIAMETERS   240.00   260.00
1.0
BETWEEN DIAMETERS   260.00   240.00
0.75
```

Again, on completion of input, the data are displayed for examination and correction if necessary.

```
THICKNESS   BETWEEN DIAMETERS
 1.00    240.00  260.00
 0.75    260.00  240.00
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
```

There is now a prompt for data describing the bow and stern end caps.

```
ENTER  SPHERICAL RADII OF BOW AND STERN DOMED END CAPS
```

If a radius smaller than the radius of the first or last diameter is given the program will reject it. Once the values are given they will be displayed for examination.

```
1 SPHERICAL RADIUS OF BOW DOMED ENDCAP  150.00
2 SPHERICAL RADIUS OF STERN DOMED ENDCAP  120.00
IS THERE AN AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
```

The thickness is the next requirement. The thickness entered should be considered as that which is suitable for connecting to the hull. Later in the program there is an opportunity to give increased thickness at the apex of the endcaps.

```
ENTER BOW END CAP THICKNESS

ENTER STERN ENDCAP THICKNESS
```

The input is echoed for examination.

```
1.00   0.75  BOW ENDCAP AND STERN ENDCAP THICKNESS
IS THERE AN ERROR IN DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
```

In this case the line number is always 1.

This is the end of the basic data input which can be edited on restart. If editing of the basic data is not required then a restart allows the modification of the structural details of a previously generated model starting with the basic data. The next prompt is an option to create a PATRAN session file. The file is phase 1 and phase 2 data and allows the user to display the shell and sail with PATRAN. The full structural model including ring stiffeners can be translated to PATRAN phase 2 data by the use of the translator program VASPAT. Thus the power of PATRAN is available to the PATRAN user for modelling changes or results processing.

5.2 Structural Data Input

The start of the structural detailing begins with the specification of the bulkheads.

```
ENTER THE NUMBER OF BULKHEADS
**
ENTER THE BULKHEAD LOCATIONS AS DISTANCE FROM BOW
ENTER BULKHD   1 DIST
**
ENTER BULKHD   2 DIST
**
```

The input data are listed for inspection

```
NO   DISTANCE
 1    **
 2    **
IS BULKHEAD DATA CORRECT   YES = 0   NO = 1
0
ENTER 2 BULKHEAD PLATE THICKNESSES
BULKHD   1 THICKNESS
**
BULKHD   2 THICKNESS
**
NO.  BULKHD  THICKNESS
 1        **
 2        **
IS BULKHEAD CORRECT     YES = 0    NO = 1
```

The number of circumferential elements is requested next. The maximum number is currently set at 16, which can be increased by changes within the SUBHUL.PAR file. The number chosen sets the number of circumferential shell elements as well as the number of curved beam elements making up the ring stiffeners. It also sets the number of elements forming the bulkheads.

```
ENTER NUMBER OF CIRCUMFERENTIAL ELEMENTS (MAX. 16)
**
```

There are two modelling options, a full cylinder or a half cylinder. Each will be given the appropriate boundary conditions later. The half model is more economical, but has limitations such as not being able to predict all the buckling or vibration modes.

```
FOR HALF CYLINDER MODEL ENTER 1
  FULL CYLINDER MODEL ENTER 2
  **
```

The ring stiffeners are defined with the following prompts.

```
ARE SHELL STIFFENERS REQUIRED
YES=0
NO=1
0
```

There are two methods of defining the ring stiffener sizes. One requires the cross-section area, moment of inertia, and eccentricity of the cross-section neutral axis from the centre of the plate thickness to which it is attached. The other requires the dimension of the T section as flange width and thickness and web depth and thickness (see Figure 5.1).

```
CHOOSE METHOD FOR DEFINING RING STIFFENER SIZE
1 = CROSSECTION PROPERTIES
2 = T SECTION DIMENSIONS
1
```

The program prompts for the stiffeners that are placed at each of the diameters specified in the basic data. These stiffeners are in some cases larger than those used in the spaces between them, often being used by the designer in place of bulkheads. It is important to note that negative eccentricity places the ring stiffener on the inside and positive places it on the outside. The eccentricity includes half the local hull shell thickness.

```
FOR EACH DIAMETER AND DISTANCE ENTER THE RING STIFFENER
CROSSECTION AREA, MOMENT OF INERTIA AND ECCENTRICITY
(NOTE NEGATIVE ECCENTRICITY PLACES STIFFENER ON INSIDE)

NO. DIAMETER DISTANCE
 1   240.00    0.000
** ** **
NO. DIAMETER DISTANCE
 2   260.00   500.00
** ** **
NO  DIAMETER DISTANCE
 3   240.00   1000.00
** ** **
```

In the display of the input the equivalent rectangular cross section, which is required for the curved beam representing the ring stiffener, is given.

```
NO   AREA  MOM-INERTIA ECCENTRICITY  WIDTH   DEPTH
 1   **      **     **        **      **
 2   **      **     **        **      **
 3   **      **     **        **      **
ARE THE VALUES CORRECT
YES=0
NO=1
0
```

The spaces between the basic diameters and the distances to are listed, and the number of ring stiffeners between them requested.

```
FOR EACH SPACE AND DIST LISTED BELOW
ENTER THE NUMBER OF RING STIFFENERS BETWEEN
```

```
NO.   SPACING   DISTANCE
 1    500.000    500.000
 2    250.000    750.00
 3    250.000   1000.000
10 5 5
ARE THE VALUES CORRECT
YES=0
NO=1
0
```

The size of the stiffeners between the basic diameters must now be specified. These are sized in the same way as the stiffeners for the basic diameters. They may differ in size in each of the spaces.

```
FOR EACH SPACE AND DISTANCE LISTED BELOW, ENTER
THE CROSSECTION AREA, MOMENT OF INERTIA AND THE ECCENTRICITY
OF THE RING STIFFENER
(NEGATIVE ECCENTRICITY PLACES STIFFENER ON INSIDE)

NO   SPACING    DISTANCE
1     ***        ***
*** *** ***
2     ***        ***
*** *** ***
ARE VALUES CORRECT
YES = 0
NO = 1
0
EQUIVALENT CURVED BEAM CROSSECTION
SPACE   BEAM WIDTH   BEAM DEPTH   ECCENTRICITY
 1        ***          ***          ***
 2        ***          ***          ***
ARE VALUES CORRECT
YES = 0
NO = 1
```

Once the stiffeners are specified the number of elements between them is required. The number used should be based on the detail in stress and deflection required in the shell between the stiffeners weighed against the size of the model. Great detail such as local buckling and vibration should be obtained with a partial model perhaps between two bulkheads or large ring frames.

```
ENTER THE NUMBER OF SHELL ELEMENTS BETWEEN RING BEAMS
2
ARE THE ELEMENTS BETWEEN BEAMS= 2 CORRECT
YES=0
NO=1
0
```

The number of axial elements in the domed end caps is the next requested input.

```
ENTER THE NUMBER OF AXIAL ELEMENTS IN DOMED END CAPS
**
```

After the number of axial elements in the end caps has been entered the user is prompted for the type of element to be used at the apex of the caps. The curvilinear quadrilateral should be used for in water vibration analysis where it is better suited for connecting to fluid or panel elements which cannot be degenerated to triangular form. The curvilinear triangular shell element is a degenerated form of the quadrilateral shell and is best used for stress and in-air vibration analysis.

CHOOSE ELEMENT TYPE FOR END CAP APEX
0 = CURVILINEAR QUADRILATERAL SHELL
1 = CURVILINEAR TRIANGULAR SHELL
**NOTE OPTION 0 SHOULD BE CHOSEN FOR USE WITH FLUID MASS MODEL

If the number of endcap axial elements is greater than 1 the thickness of the end cap can be modified.

DO YOU WISH TO MODIFY END CAP THICKNESS YES = 0 NO = 1
0

A yes answer will produce the following prompts one for each axial node location. In this way the thickness can be tapered from the apex of the bow to the hull shell and from the hull shell to the apex of the stern endcap as shown in Figure 5.2.

CURRENT LOCAL BOW END CAP THICKNESS **
ENTER NEW THICKNESS AT AXIAL STA 1 OF 4
**
CURRENT LOCAL BOW END CAP THICKNESS **
ENTER NEW THICKNESS AT AXIAL STA 2 OF 4
**
CURRENT --------------

Then for the stern end cap,

CURRENT LOCAL STERN END CAP THICKNESS **
ENTER NEW THICKNESS AT AXIAL STA 1 OF 4
**
CURRENT --------------

At this stage the program displays an estimate of the number of shell nodes and degrees of freedom in the model that has been created. If the numbers are too large for the computer then the user will have to modify the model.

NUMBER OF SHELL NODES= ***
NUMBER SHELL DEGREES OF FREEDOM=****
IF NUMBER OF DEGREES OF FREEDOM TOO HIGH ENTER 1 TO RESTART
ENTER 0 TO CONTINUE
0

The material properties can be the same for the total structure or they can be different for the shell, the ring stiffeners and the bulkheads.

MATERIAL PROPERTIES ARE SAME THROUGHOUT STRUCTURE
YES = 0
NO = 1
0
ENTER YOUNGS MODULUS-POISSONS RATIO-DENSITY FOR STRUCTURE
** ** **

GEOMETRY AND ELEMENT COMPLETE

At this stage the geometry has been defined and stored on the PREFX.DAT file and the model has been generated and will be stored on the PREFX.SBH file. The user can stop here and restart later or continue and produce VAST analysis files. There is also an option at this time to examine the ring stiffeners and to plot them on the outline of the hull. The stiffeners can be changed individually in size and location from one side to another or they can all be converted from one side to the other of the hull by a single input. An example of the beam data is shown in Table 4.1.

TO END AND PRINT GEOMETRY AND ELEMENT DATA ENTER 1
TO EXAMINE RING STIFFENER ARRANGEMENT ENTER 2
TO PROCEED AND GENERATE A VAST ANALYSIS FILE ENTER 3

See the section on display graphics if option 2 is selected.

5.3 Sail Model Data Input

The sail model option allows the user to visualize the presence of a sail on the pressure hull. There is no structural connection to the hull and the model cannot be used for analysis purposes. The following prompts assumes there is an existing basic data file.

```
RUN SUBHUL
INPUT A 5 CHARACTER DATA FILE NAME
EBOAT
BASIC GEOMETRY DATA EXIST ON FILE EBOAT.DAT
CONTINUE = 0
TO OVERWRITE = 1
EDIT OR VIEW DATA = 2
2
SAIL IS NOT INCLUDED WITH PRESSURE HULL
ENTER 0 TO CONTINUE
   1 TO CHANGE
1
SAIL TO BE INCLUDED
YES = 0
NO = 1
0
SAIL IS INCLUDED WITH PRESSURE HULL
ENTER 0 TO CONTINUE
   1 TO CHANGE
0

TITLE: TEST OF AXISYMMETRIC MODEL
ENTER 0 TO CONTINUE
   1 TO CHANGE
0
UNITS CHOSEN FOR DIMENSION AND FORCE = mm.  AND N
CORRECT  YES=0  NO=1
0
AXISYMMETRIC PRESSURE HULL FORM
IS HULL FORM CORRECT
YES=0
NO=1
```

0
NUMBER OF DIAMETERS DESCRIBING HULL FORM 10

DIAMETERS AND DISTANCES CHOSEN

1	4900.00	0.00
2	6400.00	2000.00
3	7400.00	4700.00
4	7600.00	10500.00
5	7600.00	31800.00
6	7600.00	52500.00
7	7340.00	58500.00
8	6400.00	64500.00
9	4220.00	70500.00
10	1370.00	76500.00

IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
THICKNESS BETWEEN DIAMETERS

1.00	4900.00	6400.00
1.00	6400.00	7400.00
1.00	7400.00	7600.00
1.00	7600.00	7600.00
1.00	7600.00	7600.00
1.00	7600.00	7340.00
1.00	7340.00	6400.00
1.00	6400.00	4220.00
1.00	4220.00	1370.00

IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
1 SPHERICAL RADIUS OF BOW DOMED ENDCAP 2500.000
2 SPHERICAL RADIUS OF STERN DOMED ENDCAP 800.000
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
1.00 1.00 BOW ENDCAP AND STERN ENDCAP THICKNESS
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
IS A PATRAN SESSION FILE TO BE CREATED
YES = 0
NO = 1
1
ENTER NO OF BULKHEADS
0
ENTER NUMBER OF CIRCUMFERENTIAL ELEMENTS (MAX. 16)
6
FOR HALF CYLINDER MODEL ENTER 1
FULL CYLINDER MODEL ENTER 2
2

```
ARE SHELL RING STIFFENERS REQUIRED
YES=0
NO=1
1

FOR EACH SPACE LISTED BELOW
ENTER THE NUMBER OF AXIAL ELEMENTS DESIRED:
NO.    SPACING
1      2000.000
2      2700.000
3      5800.000
4      21300.000
5      20700.000
6      6000.000
7      6000.000
8      6000.000
9      6000.000
1 1 3 9 9 3 3 3 3
NUMBER OF AXIAL ELEMENTS     SPACE
     1            2000.000
     1            2700.000
     3            5800.000
     9           21300.000
     9           20700.000
     3            6000.000
     3            6000.000
     3            6000.000
     3            6000.000
ARE THE ELEMENT NUMBERS CORRECT
YES=0
NO=1
0
ENTER THE NUMBER OF AXIAL ELEMENTS IN DOMED END CAPS
2
NUMBER OF SHELL NODES= 714
NUMBER OF SHELL DEGREES OF FREEDOM=3570
IF NUMBER DEGREES OF FREEDOM TOO HIGH ENTER 1 TO RESTART
ENTER 0 TO CONTINUE
0
MATERIAL PROPERTIES ARE SAME THROUGHOUT STRUCTURE
YES = 0
 NO = 1
0
ENTER YOUNGS MODULUS-POISSONS RATIO-DENSITY FOR STRUCTURE
200000 .3 .00000734
ENTER DISTANCE TO SAIL LEADING EDGE FROM FWD PERP
 10500
```

See Figure 5.3 for explanation of sail dimensions.

```
ENTER DISTANCE TO SAIL TRAILING EDGE FROM FWD PERP
31800
DIST TO SAIL LEADING EDGE  10500.000
DIST TO SAIL TRAILING EDGE  31800.000
```

```
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
ENTER THE SAIL VERTICAL HEIGHT FROM SUB CENTERLINE
8000
ENTER THE DIST TO BOTTOM OF THE SAIL FROM CENTERLINE
3400
 8000.000 3400.000 HEIGHTS OF SAIL
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
ENTER THE NUMBER OF SAIL CHORDWISE ELEMENTS
 9
ENTER THE NUMBER OF VERTICAL ELEMENTS
 4
NUMBER OF CHORDWISE AND VERTICAL ELEMENTS    9   4
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
ENTER THE SAIL PLATE THICKNESS
1
   1.000 SAIL PLATE THICKNESS
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
GEOMETRY AND ELEMENT GENERATION COMPLETE

TO END AND PRINT GEOMETRY AND ELEMENT DATA ENTER 1
TO PROCEED AND GENERATE A VAST ANALYSIS FILE ENTER 3
1
```

At this point the structural PREFX.SBH has been created and the user can stop or continue on to create a VAST data file and plot the model (see Figure 5.4).

5.4 VAST Analysis Input

To conduct a VAST analysis with the model further input is required. A VAST geometry and element connectivity file PREFX.GOM must be created, along with boundary conditions, load and, in the case of vibration analysis, mass files. A master control file PREFX.USE to control the operation of VAST must also be created. If the basic data and structural model data have been created in a previous terminal session , then a restart of SUBHUL will take the user to the beginning of the VAST analysis input. Restart can also be used for specifying new types of analysis or new loading conditions; however, in most cases, the user will wish to continue with the VAST input directly from the structural data input phase. In this case the option

TO PROCEED AND GENERATE A VAST ANALYSIS FILE is chosen.

The decision to proceed results in the following prompt.

IS FLUID INTERACTION TO BE CONSIDERED

YES = 0
NO = 1

Fluid interaction need only be considered if a vibration analysis or a dynamic response analysis is to be conducted. If such is the case the following prompt appears.

ENTER FLUID METHOD TO BE USED
1 = FLUID ELEMENT METHOD
2 = SURFACE PANEL METHOD
1

The choice of the fluid element results in the generation of interface elements and up to five layers of fluid elements around the hull. The choice of the surface panel method will generate panels matching the surface grid of the hull shell elements. The surface panel method is in most cases the more efficient of the two methods and should be chosen for large models.

ENTER NUMBER OF FLUID LAYERS (MAX = 5)
**

The next decision the user must make is the choice of the type of analysis. SUBHUL is currently limited to static analysis for stress and buckling, and to vibration analysis. The effect of the ambient pressure on the vibrations frequency can be determined.

5.4.1 Vibration Analysis

Vibration analysis in SUBHUL covers vibration of the pressure hull in air and in water. This is option 3 in the following option list. The affect of the ambient pressure load on the vibration frequencies can also be accounted for if a preliminary static analysis (Option 6) is carried out followed by an eigen analysis (Option 7). This is accomplished by the selection of option 6 followed by the selection of option 7 from the option list.

ENTER TYPE OF ANALYSIS
1 = STATIC
2 = BUCKLING RUN #1 (TO GET INITIAL STRESSES)
3 = NATURAL FREQUENCY
5 = BUCKLING RUN #2 (CRITICAL LOAD)
6 = NATURAL FREQUENCY RUN #1(HULL UNDER PRESSURE)
7 = NATURAL FREQUENCY RUN #2(HULL UNDER PRESSURE)
3

Because the fluid interaction option was previously selected type 3 is used for the analysis option. This will produce a vibration analysis in which the effect of the surrounding fluid is included.

IS BANDWIDTH REDUCTION REQUIRED
YES=1
NO=0

The bandwidth option appears for all types of analysis. Its use results in efficient packing of the stiffness matrix and reduces the computer space requirements and the time required for the analysis. It should be chosen for all but the simplest models.

ENTER TYPE OF NATURAL FREQUENCY CALCULATIONS
1=DIRECT ITERATION
2=SUBSPACE ITERATION (BEST FOR LARGE PROBLEMS)

The direct iteration is best chosen if a restart to obtain additional frequencies is contemplated. This method is also best for systems having distinct eigenvalues, and when only a few frequencies are required. It is not the best when close or identical eigenvalues are involved. For further information see the VAST user's manual section on eigenvalue analysis.

GEOMETRY DATA CHECK
NO = 0
YES =3

A geometry data check can be carried out as preliminary run of the model with VAST. This will carry out model integrity tests as listed on page B-22 in the VAST user's manual (Version 6.0).

TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0

SUBHUL will plot the finite element model by calling VASTG. The plot will display all or portions of the model. It will, through use of the cursor, identify nodes, and elements can be numbered. A typical plot is shown in Figure 5.5. The plotting commands are demonstrated in Section 6.2.

DEFINE FULL CYLINDER MODEL BOUNDARY CONSTRAINTS
POSITIVE DEFINITE SYSTEM CONSTRAINED AT ENDCAPS=3
POSITIVE DEFINITE SYSTEM CONSTAINED AT END CAPS AND MAX DIA=4
UNCONSTRAINED MODEL=5
BOUNDARY CONDITIONS WITH VASTBC AND SCREEN CURSOR=6

When continue is chosen the request to define boundary is displayed. The positive definite model is constrained against translation in in X,Y and Z and from rotation about X,Y and Z. This option is best used for static analysis. Option 3 constrains the hull at forward the endcap in X,Y and Z and against rotation about X, and at the aft endcap against translation in Y and Z. Option 4 constrains the model in Y and Z at the endcaps and against translation in X at the maximum diameter and about X at the aft endcap. For vibration analysis the unconstrained or free free option is the best choice as it better represents the actual situation. Option 6 allows the user to choose the boundary conditions with the screen cursor through the use of the program VASTBC (see Appendix C for instructions).

TO PLOT THE BOUNDARY CONDITIONS ENTER 2
TO CONTINUE ENTER 0

The boundary conditions will be located as vectors on a plot of the finite element model at the nodes to which they are applied. See Figure 5.6 for option 3 and Figure 5.7 for option 4. The plotting is accomplished as in the plotting of the finite element model by a call to VASTG within SUBHUL.

IS THE EFFECT OF THE SURROUNDING WATER TO BE CONSIDERED?
YES = 1 , NO = 0

The prompt is only displayed if the fluid model option has been previously chosen. This gives the user the option to use the model or to just carry out an in air vibration analysis.

LUMPED MASS CAN BE ENTERED IN TWO FORMS
MASS AND DISTANCE FROM FORWARD PERPENDICULAR

AND OR MASS AND THE NODE TO WHICH IT IS ATTACHED
(THE MASS,WHEN INPUT WITH THE DISTANCE IS DISTRIBUTED AMONGST THE ADJACENT NODES)

The non structural masses can be entered in two forms. One gives the distance and the lumped mass value. SUBHUL distributes mass entered in this form to the frames on each side of the specified distance. The other form, of node number and mass, locates the mass directly on the specified node.

```
ENTER THE NUMBER OF LUMPED MASSES LOCATED BY THEIR DISTANCE
FROM FORWARD PERPENDICULAR
2
ENTER THE DISTANCE AND THE LUMPED MASS  1
*** ****
ENTER THE DISTANCE AND THE LUMPED MASS  2
*** ****

ENTER NUMBER OF NODES WHERE LUMPED MASSES ARE TO BE ADDED
2
ENTER THE NODE NUMBER AND THE SIX COMPONENTS OF
LUMPED MASS
** *** *** *** *** *** *** ***
ENTER LAST MASS DATA
** *** *** *** *** *** *** ***
```

The nodal lumped mass that have been entered are displayed for inspection and editing.

```
LUMPED MASSES
   NODE          MASSES
  49 **    ***    ***    ***    ***    ***    ***
  50 **    ***    ***    ***    ***    ***    ***
ENTER 1 TO CONTINUE


IS THERE AN ERROR IN MASS DATA
IF YES ENTER LINE NUMBER
IF NO ENTER 0
0
```

The line numbers 49 and 50 indicate that the masses entered previously as distance and value have been distributed to 48 nodes.

```
TO PLOT LUMPED MASS ON FEM MODEL ENTER 1
TO CONTINUE ENTER 0
0
```

The mass can be plotted on the finite element model by calls within SUBHUL to VASTG or independently by VASTG itself. An example of a plot is shown in Figure 5.8. The plotting commands are demonstrated in Subsection 6.4.

```
TO PLOT MASS DIAGRAM ENTER 1
TO CONTINUE ENTER 0
1
```

There is another option for plotting mass which shows the longitudinal distribution and the transverse distribution as a bar chart or as stepped data. An example is shown in Figure 5.9.

```
CHOOSE FROM FOLLOWING PLOTTING OPTIONS
TO PLOT BAR CHART ENTER 1
TO PLOT AS STEPPED DATA ENTER 2
TO FINISH PLOTTING ENTER 0
1
```

When the option to finish plotting is chosen the following prompt appears.

```
DO YOU WISH TO INSPECT THE MASS DATA FILE
YES=1
NO=0
```

The mass file can be inspected and it will contain all the distributed masses, as well as the specific nodal masses that were input. The mass data can be edited at this time if necessary.

```
TO EDIT EXISTING MASS FILE = E
TO RETAIN EXISTING FILE = C
TO VIEW EXISTING FILE = V
TO OVERWRITE MASS FILE = D
```

The mass editing prompt will also appear on the restart to create a new input file as well as at the end of the mass input.

```
DIRECT ITERATION METHOD
FOR NATURAL FREQUENCIES ENTER 0
FOR BUCKLING ANALYSIS ENTER 1
0
```

Because the direct iteration method was previously chosen as the eigenvalue extraction method the prompt refers to it. The same prompt will occur for the buckling analysis option.

```
NATURAL FREQUENCY ANALYSIS

ENTER FIRST AND LAST MODE TO BE COMPUTED
** **
YOU HAVE CHOSEN MODE ** TO MODE ** TO BE CALCULATED
ARE THE MODES CORRECT ?
YES=1
NO=0
1
```

The user is required to enter the first and last mode to be calculated. If the model has free free boundary conditions then the first 6 modes will be rigid body modes; therefore, in order to obtain 2 elastic modes 8 frequencies must be requested.

```
DEFAULT VALUE OF ITERATIONS FOR EIGEN SOLUTION = 20
IF NUMBER OF ITERATIONS SATISFACTORY ENTER 0
ENTER NEW VALUE IF LARGER VALUE REQUIRED
0
ITERATION TOLERANCE CURRENTLY SET TO .001
IF TOLERANCE SATISFACTORY ENTER 0
```

ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0

In some cases, such as for higher modes and close eigenvalues, more than 20 iterations and a tolerance closer than .001 may be required for the solution to converge.

TOLERANCE FOR STURM SEQUENCE CHECK FOR MISSING EIGENVALUES
SET AT 0.01000 IF TOLERANCE SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0

There is the possibility that not all the frequencies have been detected by the analysis. A Strum sequence check is used in VAST to check for missing eigenvalues. If they have been missed then it will be necessary to go back and regenerate a new VAST analysis file calling for a number of iterations higher than 20 and a tolerance closer than .001. The choice of subspace iteration as a solution may also be necessary.

LINE PRINTER OUTPUT IS ON FILE SAMPH.LPT
OTHER DATA OUTPUT:
VAST DATA INPUT FILE SAMPH.USE
PRESSURE HULL GEOMETRY FILE SAMPH.SBH
VAST GEOMETRY FILE SAMPH.GOM
VAST BOUNDRY CONDITION FILE SAMPH.SMD
LUMPED MASS FILE SAMPH.MMD
GENERATE A SUBMIT COMMAND FILE SAMPH.COM (0=NO 1=YES)

On completion of the VAST analysis input, SUBHUL lists the files that have been created. At this time there is an option to generate a command file to run the analysis on a VAX computer system as a batch job. All the files are formatted and can be hard copied for future reference.

5.4.2 Static Analysis

At the prompt for type of analysis, the option for static analysis can be chosen. This option will generate the VAST data required for a static stress analysis of the pressure hull based on a uniform external pressure.

ENTER TYPE OF ANALYSIS
1 = STATIC
2 = BUCKLING RUN #1 (TO GET INITIAL STRESSES)
3 = NATURAL FREQUENCY
5 = BUCKLING RUN #2 (CRITICAL LOAD)
6 = NATURAL FREQUENCY RUN #1(HULL UNDER PRESSURE)
7 = NATURAL FREQUENCY RUN #2(HULL UNDER PRESSURE)
1

IS BANDWIDTH REDUCTION REQUIRED
YES=0
NO=1
0

Stresses must be flagged if they are required in addition to displacements.

ARE ELEMENT STRESSES REQUIRED
YES=1

NO=0
1

GEOMETRY DATA CHECK
NO = 0
YES= 3
0

ARE RESIDUAL STRESSES TO BE ACCOUNTED FOR YES = 2 NO = 0
0

Residual stresses are present to some degree in the pressure hull as result of construction processes. These can be accounted for if known. A yes entry will flag VAST to expect to find data concerning the stresses in the element connectivity of the PREFX.GOM file. The user will be prompted later to supply the residual stress data.

TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0
0

DEFINE FULL CYLINDER MODEL BOUNDARY CONSTRAINTS
POSITIVE DEFINITE MODEL CONSTRAINED AT END CAPS=3
POSITIVE DEFINITE MODEL CONSTRAINED AT END CAPS AND MAX DIA=4
UNCONSTRAINED MODEL=5
BOUNDARY CONDITIONS USING VASTBC WITH SCREEN CURSOR=6
3

For static analysis a fully constrained positive definite model is required. The constraints for this are automatically applied by SUBHUL. They work best for the hydrostatic load case of the fully submerged hull. For concentrated loads such as towing loads, the reactions at the constraints should be kept to a minimum by applying compensating loads such as propeller thrust. The user can modify the constraints with the VASTBC option or by editing the boundary condition file PREFX.SMD in accordance with the requirements under the STIFFNESS MATRIX MODIFICATIONS section of the VAST User's Manual having first found the required node numbers by plotting the finite model.

TO PLOT BOUNDARY CONDITIONS ENTER 1
TO CONTINUE ENTER 0
0

The boundary conditions can be plotted at this time with SUBHUL or later by using VASTG.

LOAD DATA CHECK
NO, ENTER 0
YES, ENTER 3
0

As with the geometry check, SUBHUL will create a VAST control file by which the load data can be checked for format errors etc. The load data are entered on a separate file PREFX.LOD.

LOAD DATA CAN BE ENTERED ON A SEPARATE FILE
TO INCLUDE THESE DATA ON FILE PREFX.USE ENTER 0

TO SUPPLY ON SEPARATE FILE PREFX.LOD ENTER 1

Except for very simple loads, it is best to use a LOAD file separate from the USE file for easier inspection and manual editing if required.

ENTER A TITLE FOR THE LOAD CASE (MAX 72 CHARACTERS)

TITLE TEST OF STATIC LOADS

SELECT ELEMENT LOAD OPTIONS:
0 = NO ELEMENT LOADS ARE TO BE COMPUTED
1 = BODY FORCES, DISTRIBUTED EXTERNAL LOADS, INITIAL STRAIN TO BE COMPUTED

Elements loads are body forces, pressure loads and initial strains.

ARE CONCENTRATED LOADS TO BE APPLIED
YES = 1
NO = 0

Concentrated loads can be applied alone or in conjunction with element loads.

LOADING OF STRUCTURE UNDER GOING TRANSLATIONAL ACCELERATION AS A RIGID BODY:

FOR SELF-WEIGHT DUE TO GRAVITY, ENTER 2
FOR RIGID BODY ACCELERATION, ENTER 1
FOR ZERO ACCELERATION, ENTER 0
2

The program does not account for self-weight. If it is considered important it can be flagged. Other types of rigid body acceleration can also be considered at this time as well. In such a case self-weight, if required, must be included in the Y component of the accelerations.

IS THERE RIGID BODY ROTATIONAL MOTION

IF YES ENTER 1
IF NO ENTER 0
0

ENTER THE ACCELERATION DUE TO GRAVITY FOR SELF-WEIGHT
386

Because imperial units were chosen as inches then the acceleration due to gravity must be inches/sec**2.

ENTER SUBMARINE DEPTH IN FEET

The units for the analysis should be in millimeters or inches. In the case of millimeters the prompt will ask for the depth in metres which will be converted to mega-Pascals. If inches have been used then the depth in feet will be converted to pounds per square inch.

ARE PRINTOUTS OF NODAL LOADS, REACTIONS AND DISPLACEMENTS REQUIRED YES = 1 NO = 0

Nodal loads, reactions and displacements can be stored in the PREFX.LPT file from which they can be printed for inspection. Reactions are especially useful for checking the validity of the results. Displacement results can be graphically displayed as distortion plots or displacement contours plots with VASTG.

ARE ELEMENT STRESSES TO BE PRINTED BY LINE PRINTER
YES = 1
NO = 0

The stresses can also be stored on the PREFX.LPT file for printing. Generally it is best to display these in the form of stress contours with VASTG.

LINE PRINTER OUTPUT IS ON FILE SAMPH.LPT
OTHER DATA OUTPUT:
VAST DATA INPUT FILE SAMPH.USE
PRESSURE HULL GEOMETRY FILE SAMPH.SBH
VAST GEOMETRY FILE SAMPH.GOM
VAST BOUNDRY CONDITION FILE SAMPH.SMD
VAST LOAD DATA FILE SAMPH.LOD
LUMPED MASS FILE SAMPH.MMD
GENERATE A SUBMIT COMMAND FILE SAMPH.COM (0=NO 1=YES)

The input terminates with the listing of the pertinent files that have been created.

5.4.3 Buckling Analysis

A buckling analysis by VAST is carried out in two steps. The first step is a static analysis with a load which should be near but not greatly exceed the buckling load. The second step is to restart SUBHUL to create a control file which will instruct VAST to search for the file containing the stresses from the step one analysis.

ENTER TYPE OF ANALYSIS
1 = STATIC
2 = BUCKLING RUN #1 (TO GET INITIAL STRESSES)
3 = NATURAL FREQUENCY
5 = BUCKLING RUN #2 (CRITICAL LOAD)
6 = NATURAL FREQUENCY RUN #1(HULL UNDER PRESSURE)
7 = NATURAL FREQUENCY RUN #2(HULL UNDER PRESSURE)
5

IS BANDWIDTH REDUCTION REQUIRED

YES = 0
NO = 1
0
CHOOSE EIGENVALUE SOLUTION METHOD FOR BUCKLING ANALYSIS
1 = DIRECT ITERATION
2 = SUBSPACE ITERATION

As in the case of vibrations, there are two options for solution methods. The direct iteration is best chosen if a restart to obtain additional eigenvalues is contemplated. This method is also best for systems having distinct eigenvalues, and when only a few eigenvalues are required. It is not the best when close or identical eigenvalues are involved. For further information see the VAST user's manual section on eigenvalue analysis.

GEOMETRY DATA CHECK
NO ENTER 0
YES ENTER 3
0

INITIAL STRESSES ARE REQUIRED AMONGST NODES 1 TO 377
THEY SHOULD BE PROVIDED BY A PREVIOUS ANALYSIS ON FILE PREFX.T53
IF THEY HAVE ENTER 1
IF NOT ENTER 0 TO STOP

This prompt only occurs if the initial stress file PREFX.T53 does not exist. The initial stresses are generally generated by a previous static analysis. In some cases there may be known stresses which the user may wish to use. These must not be residual stresses but stresses due to a loading case.

TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0
0

TO PLOT BOUNDARY CONDITIONS ENTER 2
TO CONTINUE ENTER 0
0

The boundary conditions are the same as used in the static analysis have been applied automatically and can be displayed at this stage.

IS THE PRINTOUT OF BUCKLING MODES REQUIRED
YES = 1
NO = 0

The buckling modes can be displayed graphically by VASTG after the completion of the VAST analysis. It is often desirable to have a hard copy of the eigenvectors of the buckling modes for reference.

BUCKLING ANALYSIS
ENTER FIRST AND LAST BUCKLING MODES TO BE COMPUTED
*** ***

The range of buckling modes of interest is entered here. Depending on the complexity of the structure these can include total collapse and interframe buckling as predicted by bifurcation buckling.

YOU HAVE CHOSEN MODE *** TO MODE *** TO BE CALCULATED
ARE THE MODES CORRECT?
YES=1
NO=0

DEFAULT VALUE OF ITERATION FOR EIGEN SOLUTION = 20
IF NUMBER OF ITERATIONS SATISFACTORY ENTER 0
ENTER NEW VALUE IF LARGER VALUE REQUIRED
0

Sometimes, such as in the case of close eigenvalues, more than 20 iterations may be required.

ITERATION TOLERANCE CURRENTLY SET TO .001
IF TOLERANCE SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED

Experience has shown that buckling modes can be missed if the tolerance is too coarse.

TOLERANCE FOR STURM SEQUENCE CHECK FOR MISSING EIGENVALUES
SET AT .01 IF TOLERANCE SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED

The Strum sequence check is used in VAST to search for missing eigenvalues. It informs the user if he must refine the tolerances in the eigenvalue solution if missing buckling modes have been detected.

LINE PRINTER OUTPUT IS ON FILE PREFX.LPT
OTHER DATA OUTPUT
VAST DATA INPUT FILE PREFX.USE
PRESSURE HULL GEOMETRY FILE PREFX.SBH
VAST GEOMETRY FILE PREFX.GOM
VAST BOUNDRY CONDITION FILE PREFX.SMD

The listing of created files of direct interest to the user indicates the end of the session.

5.4.4 Restart

A restart can be made using the same model to create a new series of VAST input files for the following situations:

(a) a change of boundary conditions
(b) a change in the non structural mass
(c) to create a added fluid mass model
(d) to change the type of analysis
(e) to change the loading case
(f) to change material properties

In each of these case the program has to be restarted.

RUN SUBHUL

INPUT A FIVE CHARACTER DATA FILE NAME
TESTS

The five character name is the name previously given to the model which serves as the PREFX of all the data files created.

PRESSURE HULL FINITE MODEL AVAILABLE ON FILE TESTS.SBH
TO CREATE A VAST INPUT FILE = 0
TO MODIFY MODEL = 1

The user has the opportunity at this stage to modify the structural details of the model but not its basic geometry. The modifications to the model that are possible are those shown in subsection 5.2 on Structural Data Input. If the option to create a VAST input file is chosen then the existing structural model is used and the following display appears.

NUMBER OF NODES ***
NUMBER OF ELEMENT GROUPS ***

NUMBER OF SHELL ELEMENT NODES ***
NUMBER OF SHELL THICKNESSES ***
NUMBER OF AXIAL NODES ***

This gives the user some idea of the size and makeup of the model. The data in this case are for an unstiffened cylinder without bulkheads. If bulkheads are present data concerning them will be displayed.

IS FLUID INTERACTION TO BE CONSIDERED
YES =0
NO =1
0

At this stage the program can be flagged that an added mass fluid model will be required for a natural frequency analysis.

FLUID MODEL FILE PREFX.AMD EXISTS
TO USE EXISTING MODEL = 1
TO CREATE NEW MODEL = 0
0

If a fluid model that matches the structure has been previously created it can be reused. If changes have been made to the structure, a new model must be created. In this example it is assumed that a fluid model is in existence. In the case of a new fluid model the prompts would be the same as terminal responses as illustrated in Section 5.4.1 on vibration analysis.

5.4.4.1 Master Control Code

VAST is controlled by a master control code which is the second record in the PERFX.USE file. The use of the control code is described on pages C1-1 to C1-7 in the VAST user manual. Basically, the control code consists of 10 digits which control the routing through VAST. It flags the following headers in accordance with the specific analysis requested.

IELEMS = element matrices generation
IBANRD = bandwidth reduction of stiffness matrix
IASSEM = assembly of stiffness and mass matrices
ISTIFM = boundary conditions
IMASSM = non structural mass and added mass
IDECOM = matrix decomposition
IEIGEN = eigenvalue analysis
ILOADS = load vectors to be computed
IDISPS = nodal point displacements
ISTRES = element stresses to be computed

In regular runs the control code is automatically set by SUBHUL. Control codes are also automatically reset for new load cases for static analysis, or restarts for additional frequencies or added mass runs. In all other restart cases SUBHUL will automatically start from IELEMS unless the user intervenes by editing the control code.

5.4.4.2 Restart Vibration Analysis

Restart of a vibration analysis can be carried out for the following reasons.
(a) requirement to obtain additional frequencies
(b) change in non structural mass
(c) change in boundary conditions

(d) addition of added fluid mass

In these cases it is not always necessary to restart VAST from the beginning. In the case of a restart for additional frequencies, SUBHUL will create the correct master control code automatically. In the case of changes to the non structural mass or to the added fluid mass, SUBHUL will start the analysis from the beginning unless the master control codes are changed in the PREFX.USE file to start from IMASSM. This can be done by editing the USE file in accordance with instructions on pages C1-1 to C1-7 of the VAST user's manual reference 1. Similarily for boundary conditions, VAST can be restarted at ISTIFM by editing the USE file, otherwise SUBHUL will start VAST at the beginning. With large models there are considerable savings in computer time if these changes to the master control codes are made.

```
ENTER TYPE OF ANALYSIS
1 = STATIC
2 = BUCKLING RUN #1(TO GET INITIAL STRESSES)
3 = NATURAL FREQUENCY
5 = BUCKLING RUN#2(CRITICAL LOAD)
6 = NATURAL FREQUENCY RUN #1(HULL UNDER PRESSURE)
7 = NATURAL FREQUENCY RUN #2(HULL UNDER PRESSURE)
3

IS BANDWIDTH REDUCTION REQUIRED
YES=0
NO=1
0
ENTER TYPE OF NATURAL FREQUENCY CALCULATION
1=DIRECT ITERATION
2=SUBSPACE ITERATION
1
FREQUENCIES FROM A PREVIOUS ANALYSIS EXIST
RESTART FOR ADDITIONAL FREQUENCIES = 1
NEW ANALYSIS = 0
1
```

If a previous analysis has been conducted and more frequencies than first specified are required then the program will be flagged to expected to calculate additional frequencies starting from the last frequency previously calculated.

```
GEOMETRY DATA CHECK
NO ENTER 0
YES ENTER 3
TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0
0
DEFINE FULL CYLINDER BOUNDARY CONSTRAINTS
POSITIVE DEFINITE  SYSTEM CONSTRAINED AT END CAPS=3
POSITIVE DEFINITE SYSTEM CONSTAINED AT END CAPS AND MAX DIA=4
UNCONSTRAINED MODEL=5
BOUNDARY CONDITIONS WITH VASTBC AND SCREEN CURSOR=6
5
IS THE EFFECT OF THE SURROUNDING WATER TO BE CONSIDERED
YES =1 , NO = 0
1
TO EDIT EXISTING MASS FILE = E
```

TO RETAIN EXISTING FILE = C
TO VIEW EXISTING FILE = V
TO OVERWRITE MASS FILE = D
C
NATURAL FREQUENCY ANALYSIS

ENTER FIRST AND LAST MODE NUMBER TO BE COMPUTED
9 12
YOU HAVE CHOSEN MODE 9 TO MODE 12 TO BE CALCULATED
ARE MODES CORRECT ?
YES=1
NO=0
1
DEFAULT VALUE OF OF ITERATIONS FOR EIGEN SOLUTION=20
IF NUMBER OF ITRATIONS SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0
ITERATION TOLERANCE CURRENTLY SET TO .001
IF TOLERANCE SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0
TO PLOT ADDED MASS MODEL
ENTER 1 TO PLOT
0 TO CONTINUE
0

5.4.4.3 Restart Static Analysis

Most restarts of a static analysis are for additional load cases. New boundary conditions are another reason. For new load cases SUBHUL will prompt the user for the data and set the master control code for VAST to start at ILOADS. Thus, there is a considerable saving in computer time as the existing decomposed stiffness can be used. If boundary conditions are changed then the master control code must be set to start VAST at ISTIFM otherwise SUBHUL will start the the analysis at the beginning which, for large problems, is wasteful in computer time.

ENTER TYPE OF ANALYSIS
1 = STATIC
2 = BUCKLING RUN #1(TO GET INITIAL STRESSES)
3 = NATURAL FREQUENCY
5 = BUCKLING RUN#2(CRITICAL LOAD)
6 = NATURAL FREQUENCY RUN #1(HULL UNDER PRESSURE)
7 = NATURAL FREQUENCY RUN #2(HULL UNDER PRESSURE)
1

IS BANDWIDTH REDUCTION REQUIRED
YES=0
NO=1
1
ARE ELEMENTS STRESSES REQUIRED
YES=1
NO=0
1
GEOMETRY DATA CHECK
NO ENTER 0

YES ENTER 3
0
ARE RESIDUAL STRESSES TO BE ACCOUNTED FOR YES=2 NO=0
2
ELEMENT RESIDUAL STRESS FILE PREFX.STR EXISTS
TO EDIT = 1
TO CONTINUE = 0
0
TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0
0
DEFINE FULL CYLINDER BOUNDARY CONSTRAINTS
POSITIVE DEFINITE SYSTEM CONSTRAINED AT ENDCAPS=3
POSITIVE DEFINITE SYSTEM CONSTAINED AT END CAPS AND MAX DIA=4
UNCONSTRAINED MODEL=5
BOUNDARY CONDITIONS WITH VASTBC AND SCREEN CURSOR=6
3
TO PLOT BOUNDARY CONDITIONS ENTER 2
TO CONTINUE ENTER 0
0
DO YOU WISH TO RUN AN EXISTING OR NEW LOAD CASE
ON ORIGINAL MODEL AMD BOUNDARY CONDITIONS
NO = 0
YES = 1
1

A no to the above prompt will result in a Master control file that will start the analysis at the beginning as it assumes a new model has been generated. A yes will start the analysis at ILOADS as it assumes that the original model and boundary conditions are to be used.

LOAD FILE EXISTS PREFX.LOD
TO USE FILE = 1
TO CREATE NEW FILE = 0
0

The choice to create a new load file will, in this case, apply the new load to the original model and boundary conditions. The program prompts for a title for the new load case.

ENTER TITLE FOR LOAD CASE (MAX 72 CHARACTERS)
TITLE
ELEMENT LOADS ARE AVAILABLE FROM PREVIOUS RUN (FILE PREFX.LOD)
TO USE ELEMENT LOADS FROM PREVIOUS CASE ENTER -1
TO GENERATE NEW ELEMENT LOADS ENTER 1
TO ELIMINATE ELEMENT LOADS ENTER 0
1

The element loads available from a previous run may be pressure and body forces. These may be reused or eliminated depending on the loading.

ARE CONCENTRATED LOADS TO BE APPLIED
YES = 1
NO = 0
0

LOADING OF STRUCTURE UNDER GOING TRANSLATIONAL
ACCELERATION AS A RIGID BODY:

FOR SELF WEIGHT DUE TO GRAVITY, ENTER 2
FOR RIGID BODY ACCELERATION,ENTER 1
FOR ZERO ACCELERATION,ENTER 0
0
IS THERE RIGID BODY ROTATIONAL MOTION

IF YES ENTER 1
IF NO ENTER 0
0
ENTER SUBMARINE DEPTH IN FEET
***
ARE PRINTOUTS OF NODAL LOADS, REACTIONS AND DISPLACEMENTS
REQUIRED YES =1 NO = 0
1
ARE ELEMENT STRESSES TO BE PRINTED BY LINE PRINTER
YES = 1
NO = 0
1

The restart is completed with the identification of files existing and created.

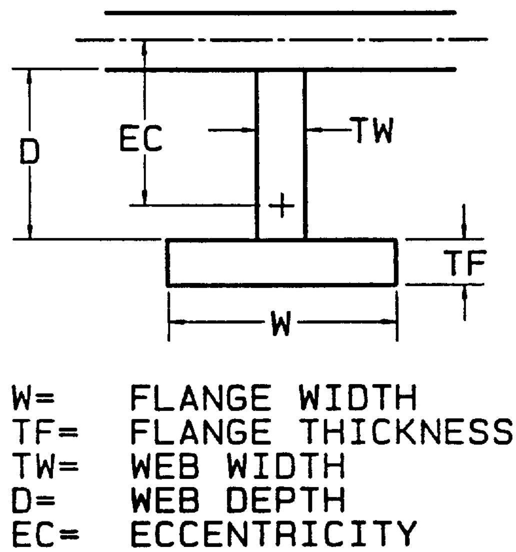


Figure 5.1 Ring Stiffener Dimensions

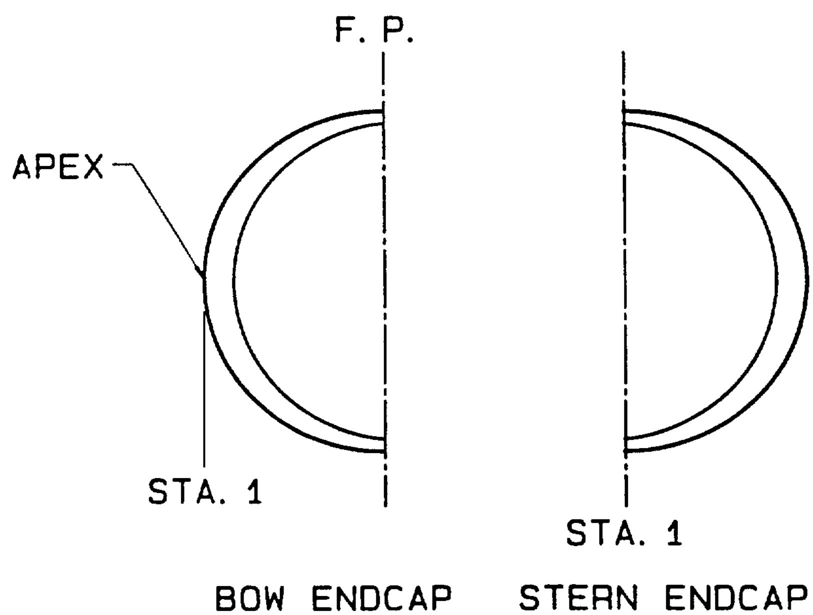


Figure 5.2 Modified Endcap Thickness

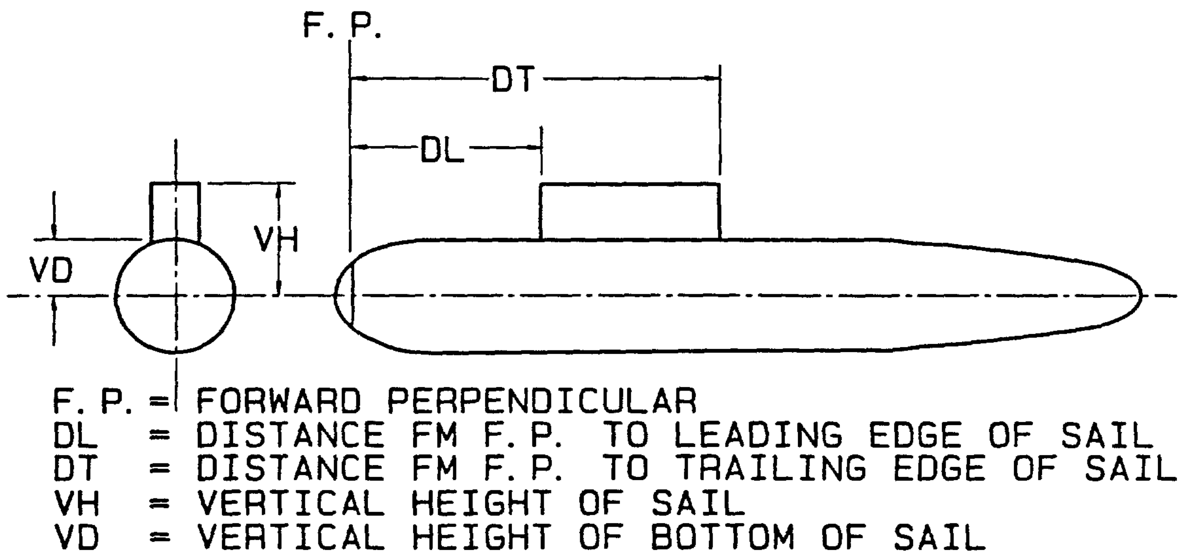


Figure 5.3 Sail Dimensions and Location

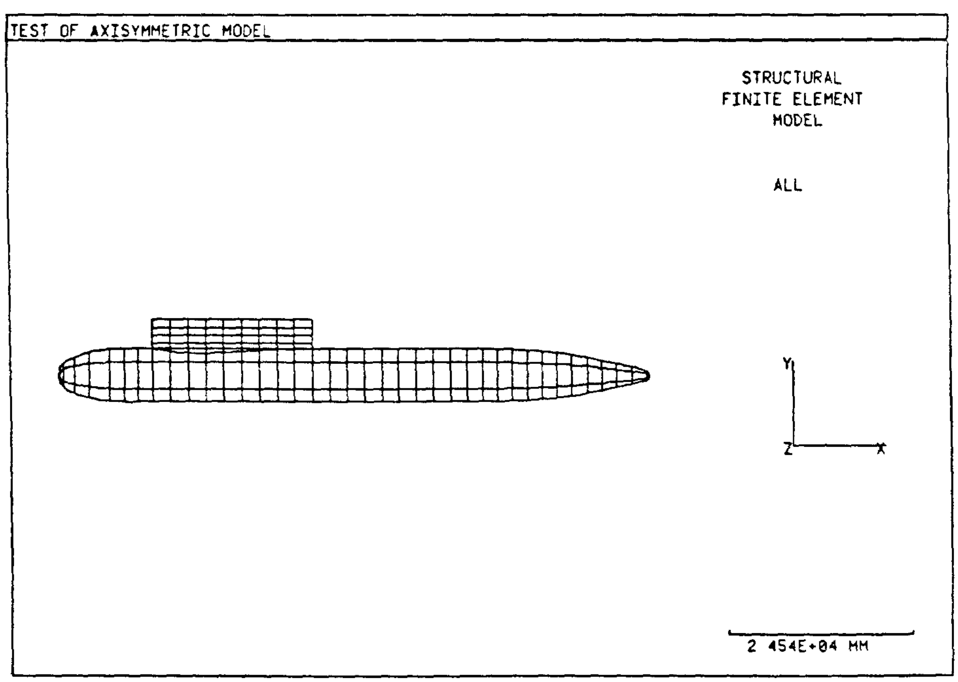


Figure 5.4 Pressure Hull and Sail Model

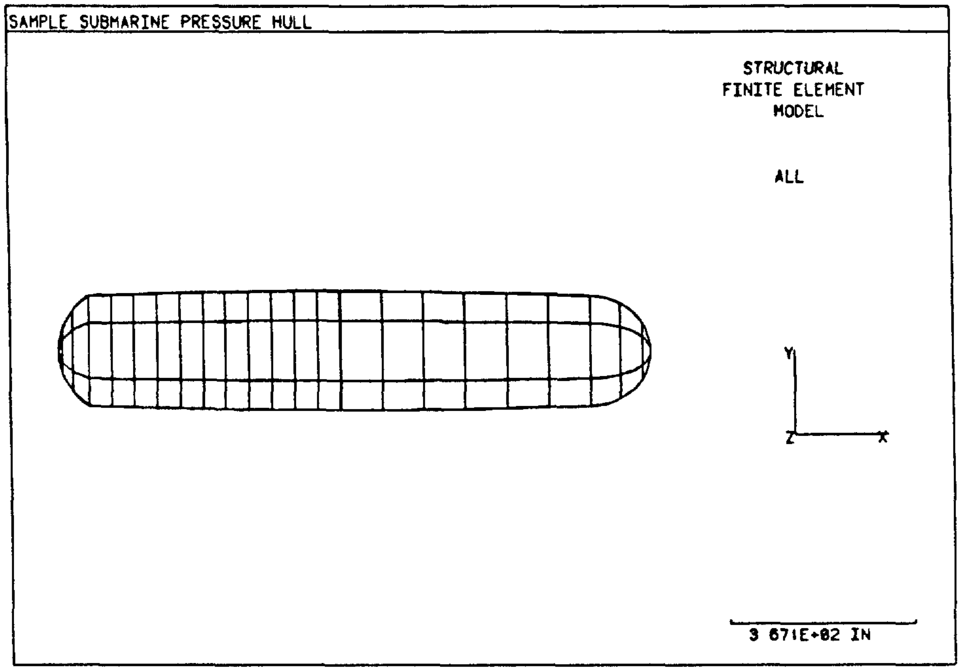


Figure 5.5 Pressure Hull Structural Finite Element Model

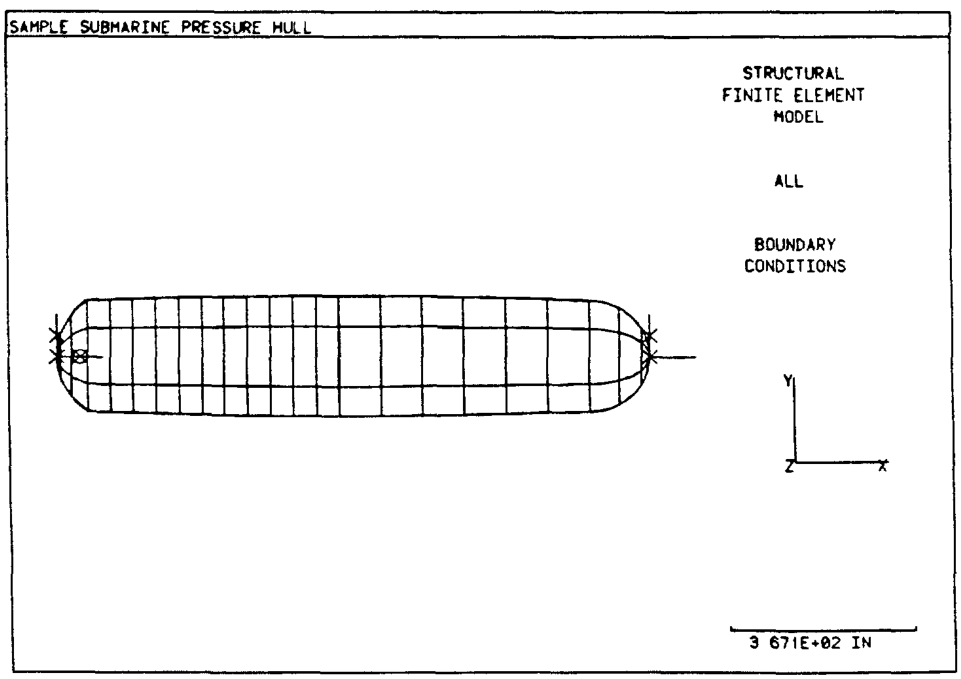


Figure 5.6 Option 3 Boundary Constraints

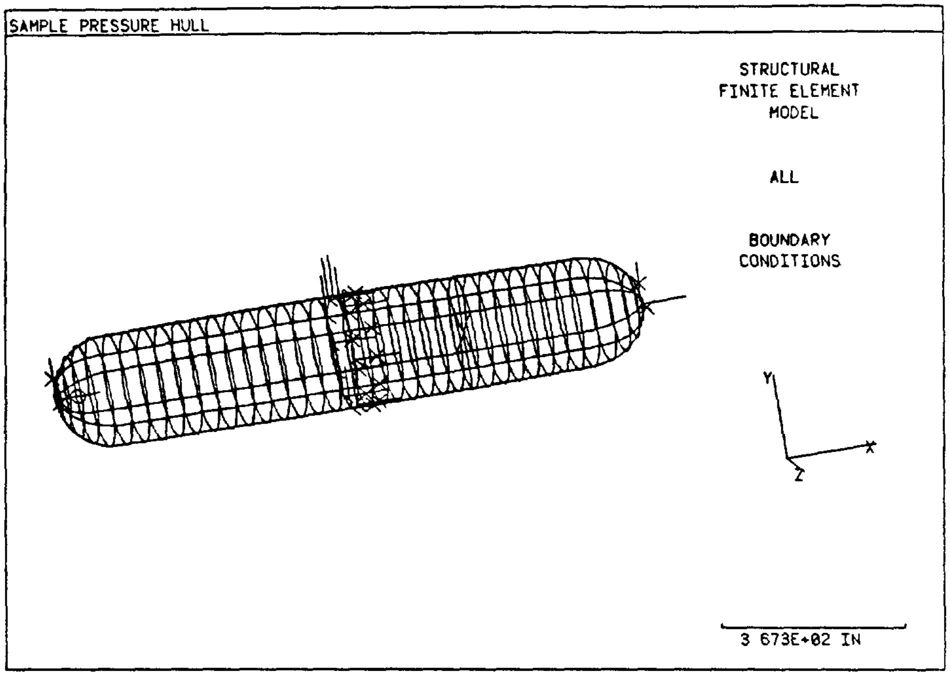


Figure 5.7 Option 4 Boundary Constraints

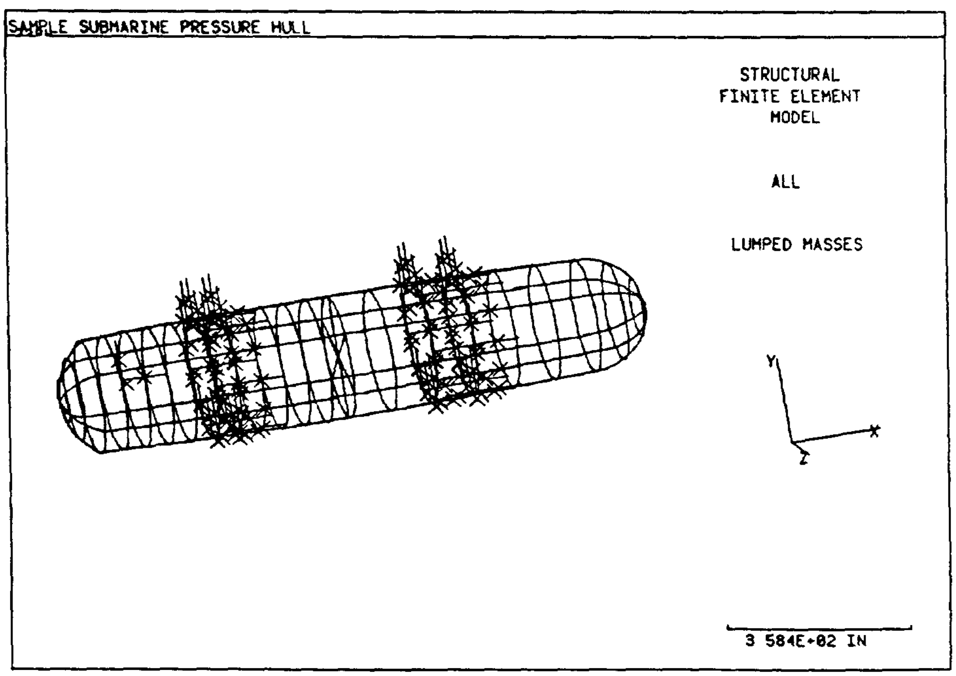


Figure 5.8 Non Structural Lumped Mass Locations

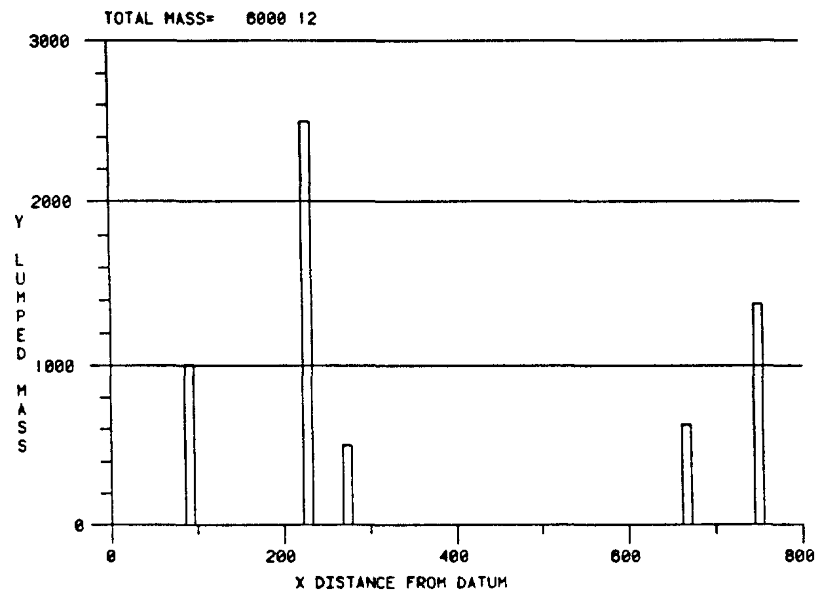


Figure 5.9 Bar Chart of Longitudinal Mass Distribution

CHAPTER 6

6. DISPLAY GRAPHICS

The ring stiffener locations, the finite element model of the pressure hull, the boundary conditions, non structural masses, and the added mass model can be displayed by prompts within SUBHUL. The results of an analysis can be plotted external to SUBHUL with the program VASTG. Except for the ring stiffener location plot and two of the mass plots, the plotting is carried out by PLOTV1, which is a subprogram of VASTG. The screen prompts for each of the graphic displays are given in the following sections.

6.1 Ring Stiffener Location

The location of the ring stiffeners relative to the shell and their longitudinal spacing can be displayed as shown in Figure 6.1. The terminal prompts occur on completion of the model data input.

```
TO END AND PRINT GEOMETRY AND ELEMENT DATA ENTER 1
TO EXAMINE RING STIFFENER ARRANGEMENT ENTER 2
TO PROCEED AND GENERATE A VAST ANALYSIS FILE ENTER 3
    2
```

The option also exists to examine the ring stiffener size and location on restart when the option to create a VAST input file appears.

```
DO YOU WISH TO EXAMINE RING STIFFENER SIZE AND LOCATION
YES = 0   NO = 1
0
```

The choice to examine gives the following terminal response in both cases.

```
TO LIST STIFFENERS = 1
TO PLOT STIFFENERS = 2
TO STOP = 3
TO CONTINUE = 0
2

WHAT IS THE LINE SPEED?
9600
```

The line speed, which is generally referred to as the Baud rate, is the data transmission rate from the computer to the display terminal. The request for line speed only occurs the first time a graphic display is called and is not repeated.

```
IDENTIFY TERMINAL TYPE ACCORDING TO RESOLUTION,
CURSOR AND COLOR CAPABILITY
ENTER 0 FOR 4006 OR EQUAL (LOW RES/NO CURS/NO COL)
    1 FOR TEKTRONIX 401* OR EQUAL
    2 FOR TEKTRONIX 4014/15 (HI RES/CURSORS/NO COL)
    3 FOR TEKTRONIX 4113 (COLOR):
1
```

The graphic system is Tektronix PLOT10 and requires any of the terminals listed or their emulation. As with line speed the terminal identification is requested only once.

```
IDENTIFY TERMINAL TYPE ACCORDING TO DIALOG CAPABILITY
ENTER 0 NO DIALOG AREA
    1 DIALOG AREA
0
```

Dialog is a capability limited to the 4113 terminals which allow scrolling of the prompts in a designated area of the screen. At this point the outline of half the shell and the beam locations will be displayed as shown in Figure 6.1.

6.2 Finite Element Model

The finite element model can be displayed during the creation of the VAST input data files described in Section 5.3. The elements of the model can be displayed according to element type. Thus the ring stiffeners can be displayed separately by plotting element type 7 and the bulkheads by plotting element types 1 or 20 and the shell by calling for element type 1. The option to display starts with the following prompt.

```
TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0
1
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION  0=NO  1=YES )
-1
```

The choice of -1 will produce the menu of commands that can be used if operation by command strings is chosen, otherwise an extended sequence of prompts will occur. It is assumed that the user will choose the command string option as it saves time once the commands are remembered. In any case the menu can always be requested.

```
AFTER THE DEFAULT VALUES ARE SET THE USER MAY NOW USE
ANY OF THE FOLLOWING COMMAND STRINGS :
    MENU  -TO DISPLAY THIS MENU
    STOP  -TO TERMINATE PLOTTING
    PLOT  -TO PLOT MODEL
    NODE  -TO PROVIDE NODE PLOTTING SPECS
    ELEM  -TO PROVIDE ELEMENT PLOTTING SPECS
    COLR  -TO PROVIDE COLOUR PLOTTING SPECS
    ELNUM -TO HAVE ELEMENTS NUMBERED
    VIEW  -TO PROVIDE SHRINK SPECS
    ZCLIP -TO PROVIDE ZCLIP SPECS

PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING
        FINITE ELEMENTS MODELS
```

The menu provides a powerful model interpretation capability whereby the user can obtain information about the nodes and elements. The option used most often is VIEW by which the model can be rotated for better inspection. The use of option ELEM will allow the user to choose the element types to be plotted. More details of the use of the graphics can be found in the VASTG user's manual, Reference 3.

```
SPECIFY LENGTH UNITS USED IN THIS ANALYSIS;
(FOR UNITS:  NIL IN. FT. MM. M.
   ENTER:  0  1  2  3  4 ):
1
```

SPECIFY FORCE UNITS USED IN THIS ANALYSIS;
(FOR UNITS: NIL LBS. KIPS. N. KN. MN.
ENTER: 0 1 2 3 4 5):
1

Units must be specified for plotting legends.

ENTER 0 FOR VIEW VECTOR APPROACH
OR 1 FOR FINITE ANGULAR ROTATIONS
1

There are two options for specifying rotation angles for the model. The vector viewing approach requires the directions cosines of the viewing vector to be input. The finite angular requires the angles of rotation about each of the global axes to be specified in the sequence of Z Y X. The Z axis is rotated first and the Y rotation is applied to the new position of the Y axis and the X rotation is applied to the new position of the X axis after the first two rotations. The finite angular rotations option is used for all examples in this manual.

DO YOU WISH TO USE DEFAULT PLOTTING SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1

The default plotting specifications are set to plot the model at zero rotations about XYZ thus presenting the model in the XY plane. The elements are plotted without node or element numbering and without shrink. These can be changed by not choosing the default option or later with command strings from the plotting menu.

ENTER COMMAND STRING

Any of the command string options listed in the menu can be entered at this time with a carriage return in between, as follows.

VIEW
* VIEW / ELEMENT / B.C. SPECIFICATIONS *

ENTER ROTATIONS ABOUT BODY-FIXED AXES Z, Y & X
AND PLOT REDUCING FACTOR (PERCENT)
10 10 10 10

The plot reducing factor is a reduction in percent of the plot. A reduction of 10 percent produces a 90 percent plot.

ENTER COMMAND STRING

PLOT

The commands could have been continued to include additional menu items. The final command always being PLOT.

AFTER PLOTTING USE :
C - TO DISPLAY COORDINATES OF SELECTED NODES
L - TO LABEL NODES WITH CURSOR
W - TO WINDOW
R - TO RECOVER ORIGINAL

PRESS "RETURN" TO PLOT

The plotting of the model (Figure 6.2) is carried out in accordance with the selected commands. The user can activate the options listed after the plot has been completed. C, L, and W use the screen cursor when chosen. To enlarge a portion of the plot, the cursor is located at the bottom left corner and then the upper right corner of the portion to be enlarged. Any keyboard entry after each location is acceptable. A rectangle will be drawn on the screen bounding the portion of the plot to be enlarged (see Figure 6.3). Any keyboard entry will cause the screen to blank and the enlarged portion to be drawn (Figure 6.4). The windowing process can be cascaded to produce larger and larger drawings of the model detail.

STOP

6.3 Boundary Condition

The plotting of boundary follows thé same sequence as the plotting of the finite element model.

```
TO PLOT BOUNDARY CONDITIONS ENTER 2
TO CONTINUE ENTER 0
2

DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION )=NO 1=YES )
 1
PROGRAM PLOTV1: VAST06 GRAPHICS PROGRAM FOR PLOTTING
         FINITE ELEMENT MODELS

DO YOU WISH TO USE DEFAULT PLOTTING SPECIFICATIONS ?
(ENTER -!=MORE INFORMATION 0=NO 1=YES )
1
ENTER COMMAND STRING
```

At this stage, if the user remembers the command BCON for plotting boundary conditions, it can be entered, otherwise the menu can be requested.

```
MENU
THE FOLLOWING ARE VALID OPTIONS
     MENU -TO DISPLAY THIS MENU
     STOP  -TO TERMINATE PLOTTING
     PLOT  -TO PROVIDE ELEMENT PLOTTING SPECS
     ELEM  -TO PROVIDE ELEMENT PLOTTING SPECS
     COLR  -TO PROVIDE COLOUR PLOTTING SPECS
     VIEW  -TO PROVIDE VIEW SPECS
     NODE  -TO PROVIDE NODE PLOTTING SPECS
     ELNU  -TO HAVE ELEMENTS NUMBERED
     SHRI  -TO PROVIDE SHRINK SPECS
     BCON  -TO PROVIDE BOUNDARY CONDITIONS
     LMAS  -TO PLOT LUMPED MASSES

ENTER COMMAND STRING

BCON
```

```
DO YOU WANT BOUNDARY CONDITIONS INDICATED ? (0=NO, 1=YES)
1
DO YOU WANT THE B. C. NUMBERED ? (0=NO, 1=YES)
0

ENTER COMMAND STRING

PLOT
```

All the options available before plus the additional options of BCON are available. The resulting plot is shown in Figure 6.5. The boundary condition symbols are explained in Figure 6.6.

```
STOP
```

6.4 Non-Structural Mass

Non-structural mass is plotted in the same manner as the model and boundary conditions.

```
TO PLOT LUMPED MASS ON FEM MODEL ENTER 1
TO CONTINUE ENTER 0
1
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO, 1=YES )
 1
PROGRAM PLOTV1: VAST06 GRAPHICS PROGRAM FOR PLOTTING
          FINITE ELEMENT MODELS

DO YOU WISH TO USE DEFAULT PLOTTING SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
ENTER COMMAND STRING
```

The command LMAS can be entered at this time or if it is not known the menu can be requested.

```
MENU
THE FOLLOWING ARE VALID OPTIONS
     MENU -TO DISPLAY THIS MENU
     STOP  -TO TERMINATE PLOTTING
     PLOT  -TO PROVIDE ELEMENT PLOTTING SPECS
     ELEM  -TO PROVIDE ELEMENT PLOTTING SPECS
     COLR  -TO PROVIDE COLOUR PLOTTING SPECS
     VIEW  -TO PROVIDE VIEW SPECS
     NODE  -TO PROVIDE NODE PLOTTING SPECS
     ELNU  -TO HAVE ELEMENTS NUMBERED
      SHRI  -TO PROVIDE SHRINK SPECS
     BCON  -TO PROVIDE BOUNDARY CONDITIONS
     LMAS  -TO PLOT LUMPED MASSES

ENTER COMMAND STRING

VIEW
```

* VIEW / ELEMENT / B.C. SPECIFICATIONS *

ENTER ROTATIONS ABOUT BODY-FIXED AXES Z, Y & X
AND PLOT REDUCING FACTOR (PERCENT)
10 10 10 10

LMAS
DO YOU WANT THE LUMPED MASSES INDICATED ? (0=NO)
1
DO YOU WANT THE L. M. NODES NUMBERED ? (0=NO)
0

ENTER COMMAND STRING

PLOT

The resulting plot is shown in Figure 6.7 and the explanation of the symbols in Figure 6.8.

STOP

There is an additional non-structural mass plotting capability in SUBHUL. This option plots the masses in the form of bar charts or stepped lines which show the longitudinal and transverse distribution. The following are the screen prompts for this plotting option.

TO PLOT MASS DIAGRAM ENTER 1
TO CONTINUE ENTER 0
1
CHOOSE FROM FOLLOWING PLOTTING OPTIONS
TO PLOT BAR CHART ENTER 1
TO PLOT AS STEPPED DATA ENTER 2
TO FINISH PLOTTING ENTER 0
1

Examples of the mass plots for option 1 are shown in Figures 6.9 and 6.10. Option 2 is shown in Figures 6.11 and 6.12

6.5 Added Fluid Mass Model

The added fluid mass model showing the surrounding fluid elements can be plotted by SUBHUL. If plotting is first initialized at this stage then prompts referring to terminal type etc. will appear, otherwise the following will be the first prompts to appear.

DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1
PROGRAM PLOTV1: VAST06 GRAPHICS PROGRAM FOR PLOTTING
FINITE ELEMENT MODELS

SPECIFY LENGTH UNITS IN THIS ANALYSIS
(FOR UNITS: NIL IN. FT. MM. M.
ENTER: 0 1 2 3 4):
1
SPECIFY FORCE UNITS USED IN THIS ANALYSIS;
(FOR UNITS: NIL LBS. KIPS. N. KN. MN.

ENTER: 0 1 2 3 4 5):
1
ENTER 0 FOR VIEWING VECTOR APPROACH
OR 1 FOR FINITE ANGULAR ROTATIONS:
1
DO YOU WISH TO USE DEFAULT PLOTTING SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=N0 1=YES)
1
ENTER COMMAND STRING

PLOT

The menu could have been requested instead of the command to plot and such commands as VIEW used. An example of an added mass model is shown in Figure 6.13. The plotting is ended as before with the command STOP.

6.6 VASTG Graphics

Once a SUBHUL model has been created and VAST data input files have been generated, it is possible to use the VASTG graphic program for direct display of the model and associated data. VASTG provides all the plotting options available in SUBHUL plus the ability to display the model with hidden lines removed. In addition, VASTG has the ability to display the applied loads and the results from a VAST analysis of the finite element model. Mode shape plots from a vibration analysis can be made as distortions of the model or as displacement contours. Buckled shapes can also be displayed as well as static displacements and stresses in the form of stress contour plots. VASTG is implemented by simply typing RUN VASTG which produces prompts similar to those described for SUBHUL. For more details on the use of VASTG refer to the VASTG User's Manual (Reference 4).

6.7 PATRAN Graphics

One of the options in SUBHUL is to produce a PATRAN session file of finite element model in the form of PATRAN phase 1 data. The PREFX.SES file can be read by PATRAN and displayed graphically. In this way hidden line removal and panel fill plotting are available, as is color shading if a color terminal is used. The following are the SUBHUL prompts and commands required to produce a PATRAN session file PREFX. SES. They will occur during input for the original model or on restart to modify the finite model.

IS A PATRAN SESSION FILE TO BE CREATED
YES = 0
NO = 1
0

The request for a session file will produce the session with no further input. The file can be read and the model displayed, with the following PATRAN commands to produce the hidden model shown in Figure 6.14.

PATRAN
ENTER DEVICE MENEONIC
INPUT "GO" "SES" "HELP", PATRAN EXECUTIVE DIRECTIVE OR STOP
SES
PLEASE INPUT NAME OF SESSION FILE
PREFX.SES

From this point on, the model will be displayed on the screen with the grid points appearing first followed by the lines patches and finally elements. By referring to the PATRAN User's Manual the model can be manipulated to produce different views with hidden lines or color shading.

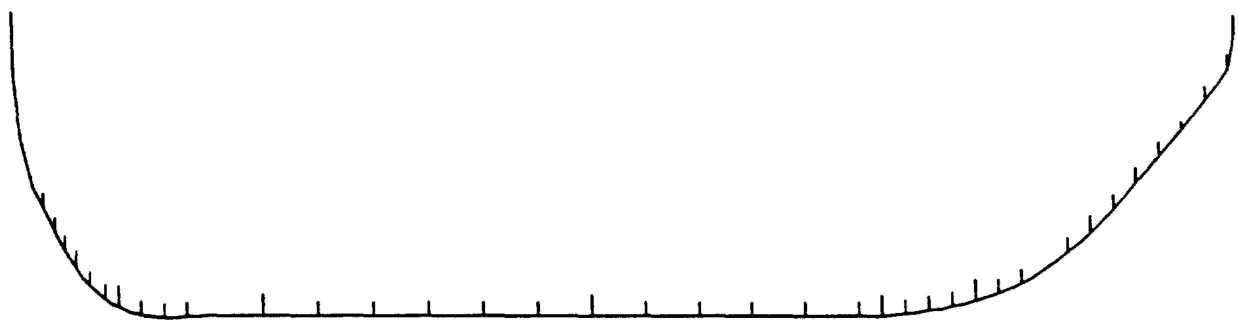


Figure 6.1 Longitudinal Spacing of Ring Stiffeners on Half Hull Outline

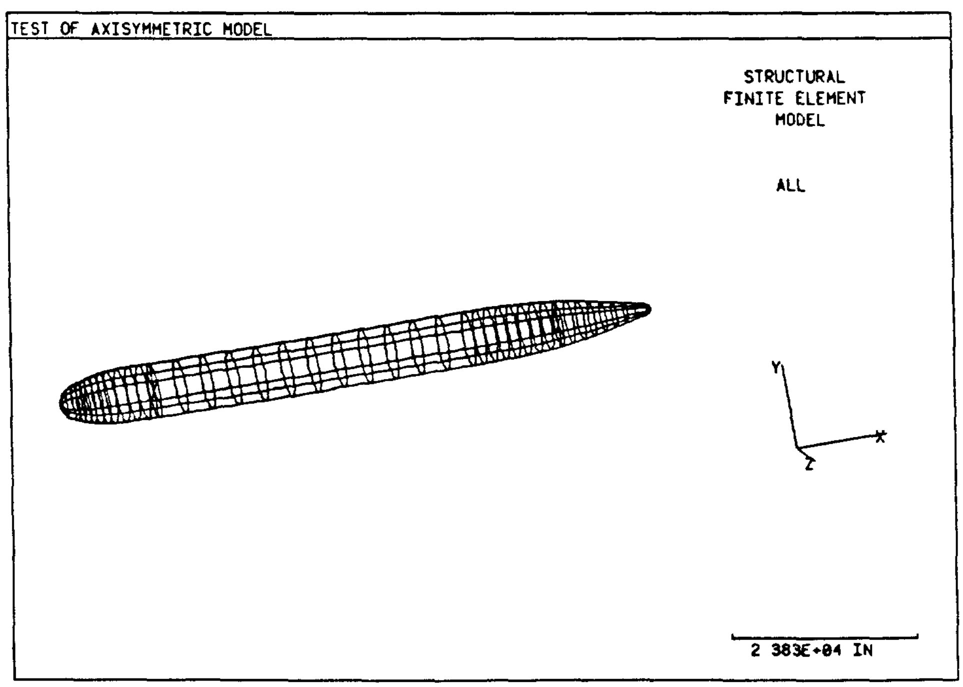


Figure 6.2 Plot of Structural Model

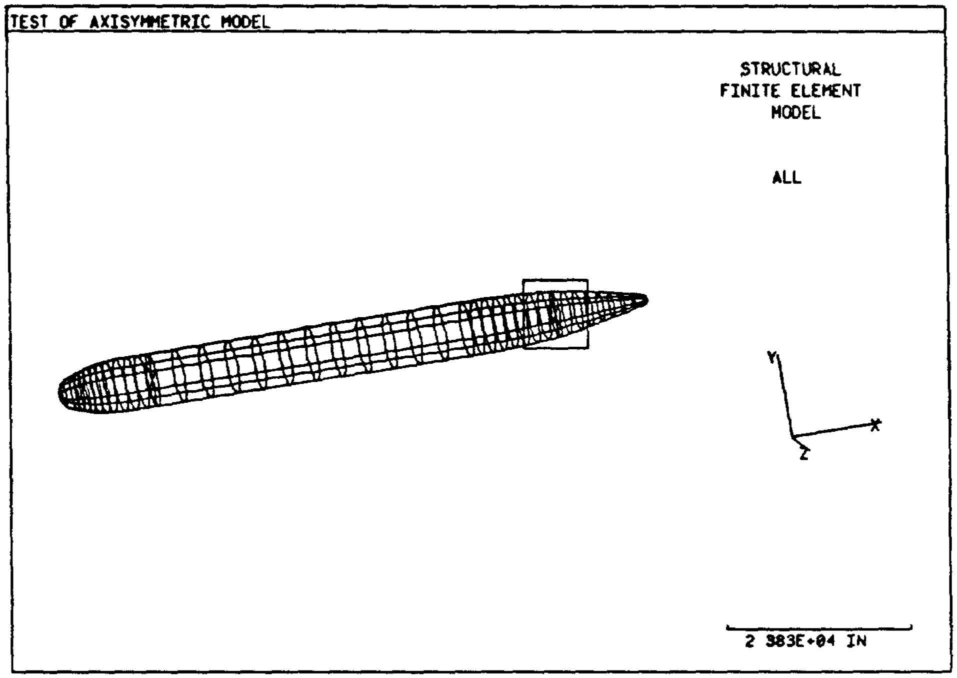


Figure 6.3 Enlarging a Portion of the Model

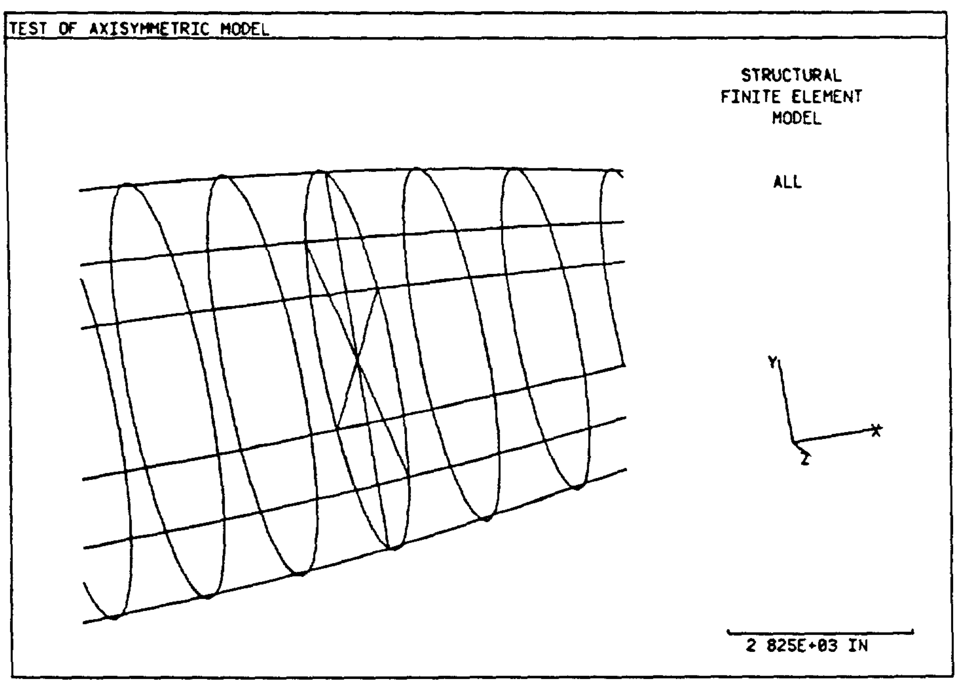


Figure 6.4 An Enlarged Portion of the Model

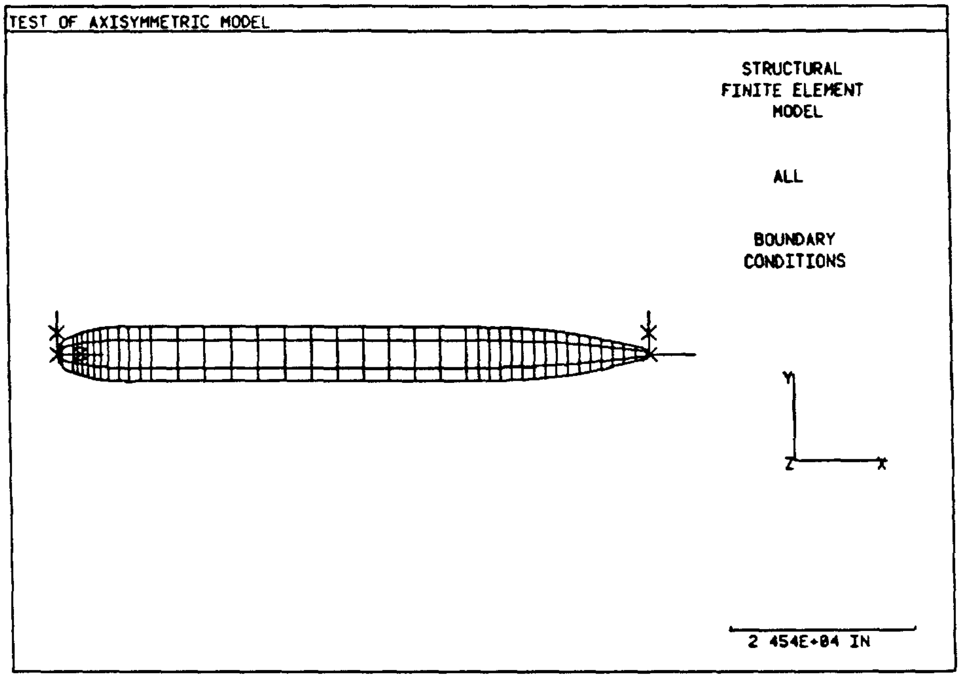


Figure 6.5 A Boundary Condition Plot

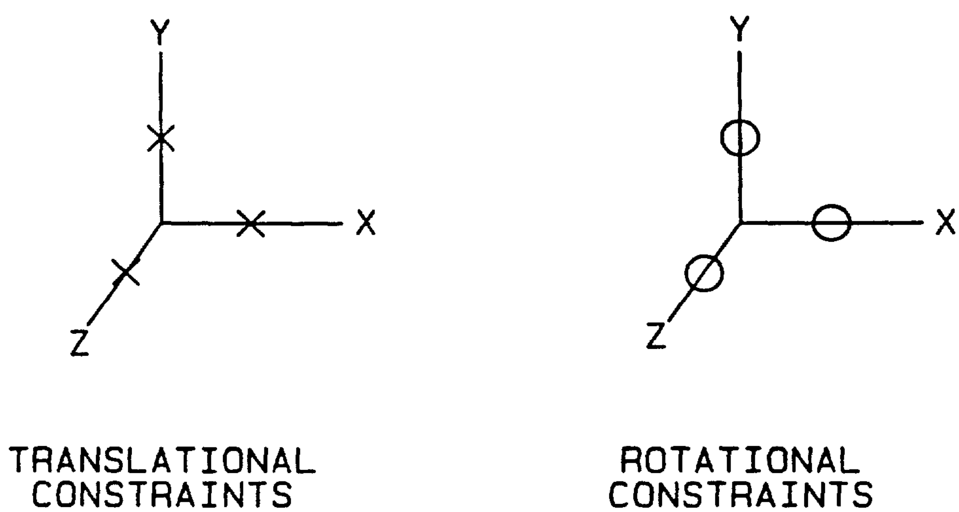


Figure 6.6 Boundary Condition Constraint Symbols

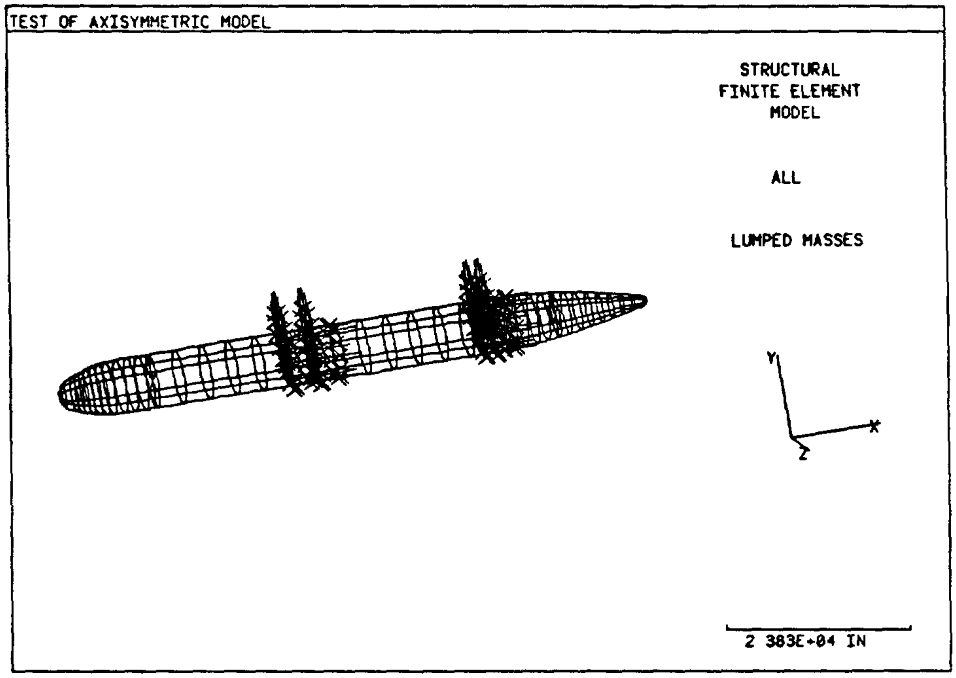


Figure 6.7 Lumped Mass Location Plot

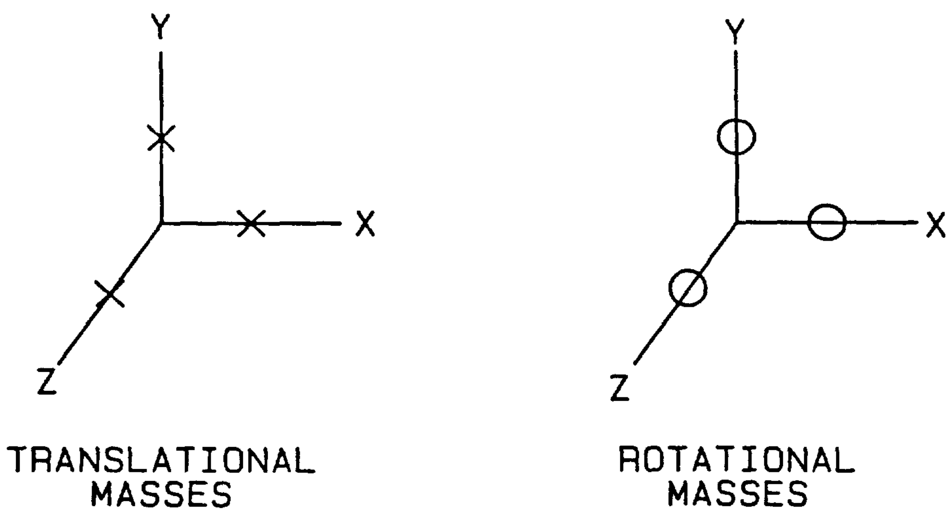


Figure 6.8 Non-Structural Mass Symbols

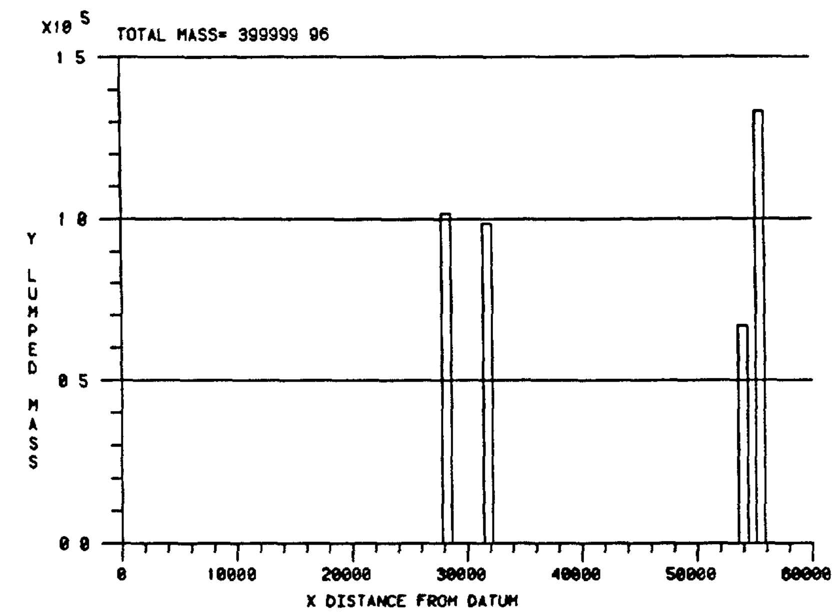


Figure 6.9 Bar Chart of Longitudinal Mass Distribution

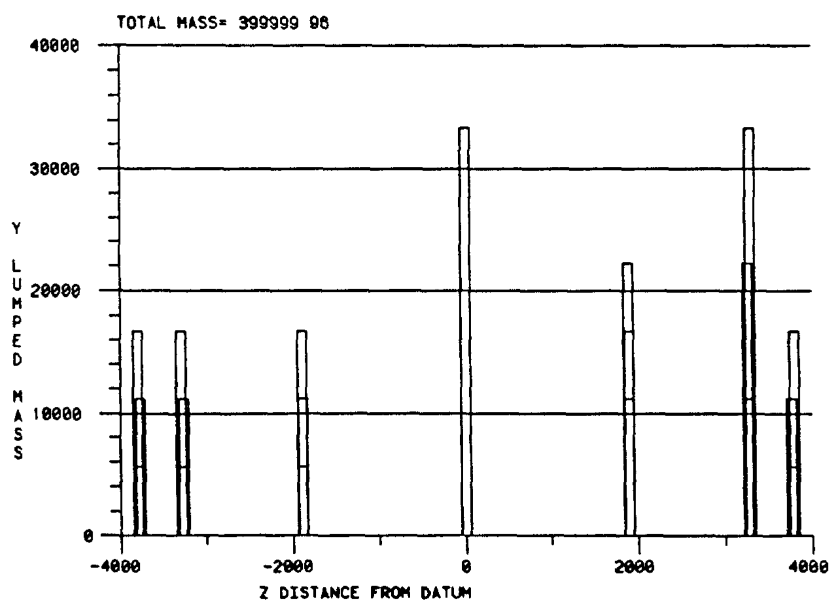


Figure 6.10 Bar Chart of Transverse Distribution of Lumped Mass

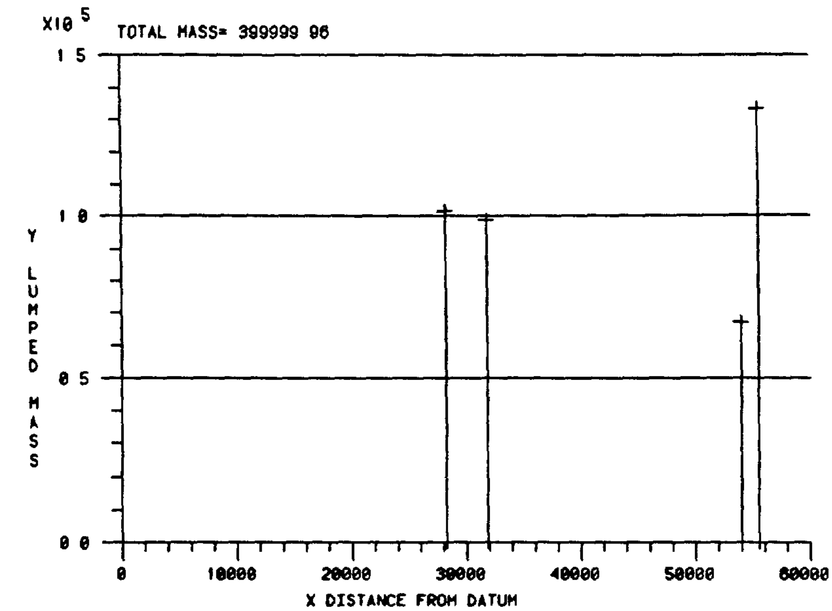


Figure 6.11 Stepped Data Option of Longitudinal Mass Distribution

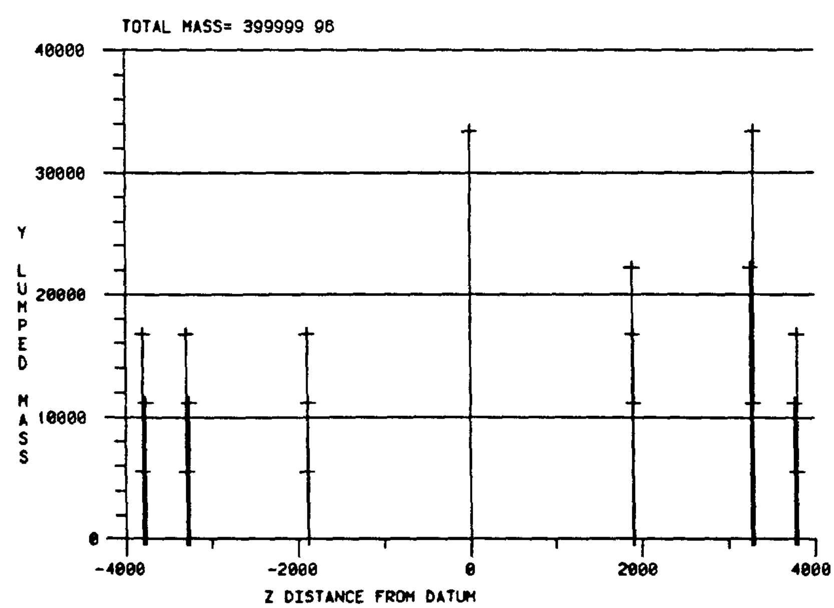


Figure 6.12 Stepped Data Option of Transverse Mass Distribution

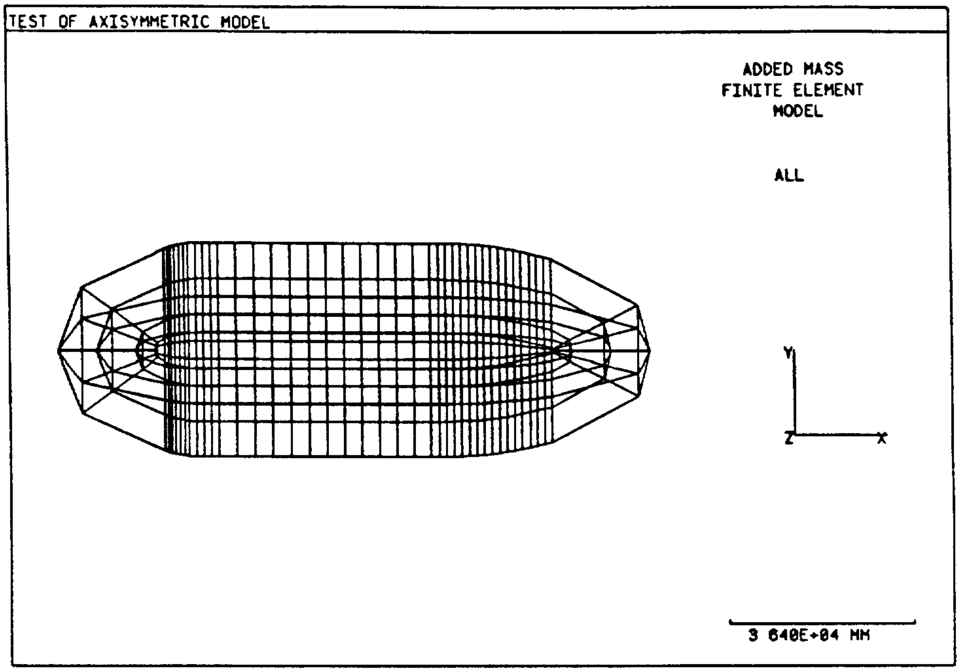


Figure 6.13 Added Fluid Mass Model of Fluid Elements

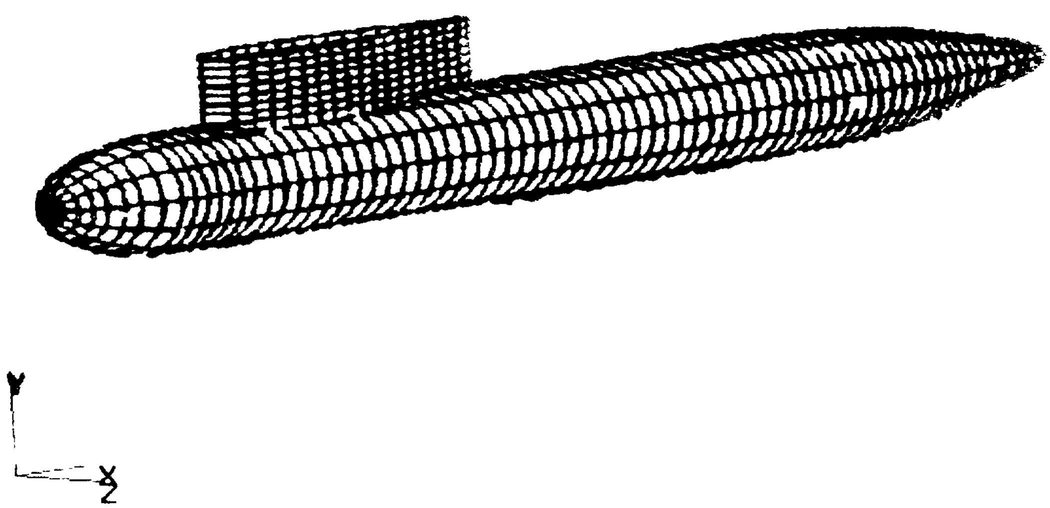


Figure 6.14 PATRAN Hidden Line Model of Submarine

CHAPTER 7

7. VAST INPUT DATA FILES

SUBHUL generates VAST input files which are required for a finite element analysis. These files are:

PREFX.USE

This file is the VAST analysis control file which contains the title of the analysis, the master control codes and the steps through the program. It is normally created by SUBHUL; however, it can be created through the use of the auxiliary program VASUSE or manually by reference to sections C, C1 and C2 of the VAST User's Manual.

PREFX.GOM

The so called geometry file is created automatically by SUBHUL. It contains the nodal coordinates and the element connectivity required for the plotting and analysis of the finite element model. Its format is described in the VAST User's Manual under Elements and Geometry section C2.

PREFX.SMD

Boundary conditions are defined in this file. Its format is described in the Stiffness Matrix Modifications Section C6 of the VAST Manual.

PREFX.MMD

The non-structural mass is defined in this file. Its format is described in the Mass Matrix Modification Section C7 of the VAST Manual.

PREFX.LOD

The model loading is defined in this file. It includes element and concentrated loads. Its format is described in Loads Section C10 of the VAST Manual.

PREFX.AMD

The added mass data is stored in this file. Its format is described in Fluid Added Mass Section D of the VAST user's Manual.

CHAPTER 8

8. TERMINAL SESSIONS

Terminal sessions are illustrated for four typical models produced by SUBHUL. These are in the form of terminal screen prompts and user responses.

8.1 Flat Deck Model

```
RUN SUBHUL
INPUT A 5 CHARACTER DATA FILE NAME
RBOAT
NEW FILE NAME
TO CONTINUE = 0
TO CHANGE NAME = 1
0
SAIL TO BE INCLUDED
YES = 0
NO = 1
1
SAIL IS NOT INCLUDED WITH PRESSURE HULL
ENTER 0 TO CONTINUE
    1 TO CHANGE
0
ENTER UP TO 90 CHARACTER TITLE
TESTS OF SUBHUL FLAT DECK MODEL

TITLE: TESTS OF SUBHUL FLAT DECK MODEL
ENTER 0 TO CONTINUE
    1 TO CHANGE
0
ENTER UNITS FOR DIMENSIONS
0 = NIL
1 = IN.
2 = FT.
3 = MM.
4 = M.
1
ENTER UNITS OF FORCE
0 = NIL
1 = LBS.
2 = KIPS.
3 = N.
4 = KN.
5 = MN.
1
UNITS CHOSEN FOR DIMENSION AND FORCE = IN.  AND LBS
CORRECT  YES=0   NO=1
0

CHOOSE PRESSURE HULL FORM
```

```
CONVENTIONAL FLAT DECK FORM ENTER 0
AXISYMMETRIC HULL FORM ENTER 1
STEPPED AXISYMMETRIC HULL FORM ENTER 2
0
ENTER THE NO OF DIA REQUIRED TO DESCRIBE THE PRESS HULL
4
ENTER THE DIAMETERS STARTING AT BOW
DIAMETER  1
163
DIAMETER  2
213
DIAMETER  3
213
LAST DIAMETER  4
108
ENTER DIAMETER LOCATIONS AS DIST FROM FWD PERP
DIST  1
0
DIST  2
207
DIST  3
2445
LAST DIST  4
2870

DIAMETERS AND DISTANCES CHOSEN
  1     163.00       0.00
  2     213.00     207.00
  3     213.00    2445.00
  4     108.00    2870.00
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
0
ENTER  3 PLATE THICKNESSES ONE FOR EACH TWO DIA
BETWEEN DIAMETERS      163.00      213.00
1
BETWEEN DIAMETERS      213.00      213.00
1
BETWEEN DIAMETERS      213.00      108.00
1
 THICKNESS   BETWEEN DIAMETERS
    1.00         163.00  213.00
    1.00         213.00  213.00
    1.00         213.00  108.00
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
0
ENTER SPHERICAL RADII OF BOW AND STERN DOMED ENDCAPS
96 66
1  SPHERICAL RADIUS OF BOW DOMED ENDCAP   96.000
2  SPHERICAL RADIUS OF STERN DOMED ENDCAP   66.000
IS THERE AN ERROR IN THE DATA
```

IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
ENTER BOW ENDCAP THICKNESS
1
ENTER STERN ENDCAP THICKNESS
1
1.00 1.00 BOW ENDCAP AND STERN ENDCAP THICKNESS
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
IS A PATRAN SESSION FILE TO BE CREATED
YES = 0
NO = 1
1
ENTER NO OF BULKHEADS
1
ENTER THE BULKHEAD LOCATIONS AS DISTANCE FROM BOW
ENTER BULKHD 1 DIST
1200
NO DISTANCE
1 1200.000
IS BULKHEAD DATA CORRECT YES = 0 NO = 1
0
ENTER 1 BULKHEAD PLATE THICKNESSES
BULKHD 1 THICKNESS
1
NO. BULKHD THICKNESS
1 1.000
IS BULKHEAD DATA CORRECT YES = 0 NO = 1
0
ENTER NUMBER OF CIRCUMFERENTIAL ELEMENTS (MAX. 16)
6
FOR HALF CYLINDER MODEL ENTER 1
FULL CYLINDER MODEL ENTER 2
2

ARE SHELL RING STIFFENERS REQUIRED
YES=0
NO=1
0
CHOOSE METHOD FOR DEFINING RING STIFFENER SIZE
1 = CROSSECTION PROPERTIES
2 = T SECTION DIMENSIONS
2
FOR EACH DIAMETER AND DISTANCE ENTER THE FLANGE WIDTH AND
THICKNESS AND WEB DEPTH AND THICKNESS
NO. DIAMETER DISTANCE
1 163.000 0.000
5 .375 10 .375
NO. DIAMETER DISTANCE
2 213.000 207.000
8 .375 15 .375

NO. DIAMETER DISTANCE
3 213.000 2445.000
8 .375 15 .375
NO. DIAMETER DISTANCE
4 108.000 2870.000
5 .375 8 .375

NO.	FLANGE	THICK	WEB	THICK	WIDTH	DEPTH	NEUT AXIS
1	5.00	0.38	10.00	0.38	0.48	11.77	6.73
2	8.00	0.38	15.00	0.38	0.49	17.54	10.17
3	8.00	0.38	15.00	0.38	0.49	17.54	10.17
4	5.00	0.38	8.00	0.38	0.52	9.45	5.61

ARE THE VALUES CORRECT
YES=0
NO=1
0
CONVERT NEUTRAL AXIS DIMENSIONS TO ECCENTRICITY BY ENTERING SHELL THICKNESS
AT FOLLOWING DIAMETERS AND DISTANCES (NEGATIVE VALUES PLACE STIFFENER ON INSIDE

NO	DIAMETER	DISTANCE
1	163.000	0.000
2	213.000	207.000
3	213.000	2445.000
4	108.000	2870.000

-1 -1 -1 -1
ARE THE VALUES CORRECT
YES=0
NO=1
0
FOR EACH SPACE AND DIST LISTED BELOW
ENTER THE NUMBER OF RING STIFFENERS BETWEEN

NO.	SPACING	DISTANCE
1	207.000	207.000
2	993.000	1200.000
3	1245.000	2445.000
4	425.000	2870.000

3 6 7 3
ARE THE VALUES CORRECT
YES=0
NO=1
0
ARE ALL RING STIFFENERS BETWEEN THE SAME SIZE
YES = 0
NO = 1
0
ENTER STIFFENER FLANGE WIDTH AND THICKNESS AND WEB DEPTH AND THICKNESS
6 .375 9 .375
ARE THE VALUES CORRECT
YES=0
NO=1
0
ENTER THE PLATE THICKNESS FOR THE FOLLOWING SPACES

(NEGATIVE VALUES PLACES STIFFENERS ON THE INSIDE OF HULL)

NO	SPACING	DISTANCE
1	207.000	0.000
2	993.000	207.000
3	1245.000	1200.000
4	425.000	2445.000

-1 -1 -1 -1
ARE THE VALUES CORRECT
YES=0
NO=1
0
EQUIVALENT CURVED BEAM CROSSECTION

SPACE	BEAM WIDTH	BEAM DEPTH	ECCENTRICITY
207.00	0.53	10.58	-7.38
993.00	0.53	10.58	-7.38
1245.00	0.53	10.58	-7.38
425.00	0.53	10.58	-7.38

ARE THE VALUES CORRECT
YES=0
NO=1
0
ENTER THE NUMBER OF SHELL ELEMENTS BETWEEN RING BEAMS
1
ARE THE ELEMENTS BETWEEN BEAMS= 1 CORRECT
YES=0
NO=1
0
ENTER THE NUMBER OF AXIAL ELEMENTS IN DOMED END CAPS
2
NUMBER OF SHELL NODES= 498
NUMBER OF SHELL DEGREES OF FREEDOM=2490
IF NUMBER DEGREES OF FREEDOM TOO HIGH ENTER 1 TO RESTART
ENTER 0 TO CONTINUE
0
MATERIAL PROPERTIES ARE SAME THROUGHOUT STRUCTURE
YES = 0
NO = 1
0
ENTER YOUNGS MODULUS-POISSONS RATIO-DENSITY FOR STRUCTURE
30000000 .3 .000733
GEOMETRY AND ELEMENT GENERATION COMPLETE

TO END AND PRINT GEOMETRY AND ELEMENT DATA ENTER 1
TO EXAMINE RING STIFFENER ARRANGEMENT ENTER 2
TO PROCEED AND GENERATE A VAST ANALYSIS FILE ENTER 3
2
DO YOU WISH TO EXAMINE RING STIFFENER SIZE AND LOCATION
YES = 0 NO = 1
0
TO LIST STIFFENERS = 1
TO PLOT STIFFENERS = 2
TO STOP = 3
TO CONTINUE =0
1

```
NO  X DISTANCE   WIDTH   DEPTH   ECCENTRICITY
 1      0.0000    478     11.767     -7.229
 2      51.750    0.532   10.580      7.375
 3103.500 0.532   10.580  -7.375
 4     155.250    0.532   10.580     -7.375
 5     207.000    0.492   17.540    -10.674
 6     348.857    0.532   10.580     -7.375
 7     490.714    0.532   10.580     -7.375
 8     632.571    0.532   10.580     -7.375
 9     774.429    0.532   10.580     -7.375
10     916.286    0.532   10.580     -7.375
11    1058.143    0.532   10.580     -7.375
12    1355.625    0.532   10.580     -7.375
13    1511.250    0.532   10.580     -7.375
14    1666.875    0.532   10.580     -7.375
15    1822.500    0.532   10.580     -7.375
16    1978.125    0.532   10.580     -7.375
17    2133.750    0.532   10.580     -7.375
18    2289.375    0.532   10.580     -7.375
19    2445.000    0.492   17.540    -10.674
20    2551.250    0.532   10.580     -7.375
21    2657.500    0.532   10.580     -7.375
22    2763.750    0.532   10.580     -7.375
23    2870.000    0.516   9.447      -6.111
TO CHANGE RING STIFFENER SIZE ENTER LINE NUMBER
ENTER -1 TO CHANGE SIGN OF ECCENTRICITY
ENTER 0 TO CONTINUE
0
TO LIST STIFFENERS = 1
TO PLOT STIFFENERS = 2
TO STOP = 3
TO CONTINUE =0
0

IS FLUID INTERACTION TO BE CONSIDERED
YES ENTER 0
NO  ENTER 1
0
ENTER FLUID METHOD TO BE USED
1 = FLUID ELEMENT METHOD
2 = SURFACE PANEL METHOD
1
ENTER NUMBER OF FLUID LAYERS  ( MAX = 5 )
3
ENTER TYPE OF ANALYSIS

1 = STATIC
2 = BUCKLING RUN #1 (TO GET INITIAL STRESSES)
3 = NATURAL FREQUENCY
5 = BUCKLING RUN #2(CRITICAL LOAD)
6 = NATURAL FREQUENCY RUN #1(HULL UNDER PRESS)
7 = NATURAL FREQUENCY RUN #2(HULL UNDER PRESS)
3
IS BANDWIDTH REDUCTION REQUIRED
```

```
YES=0
NO=1
0
ENTER TYPE OF NATURAL FREQUENCY CALCULATION
1=DIRECT ITERATION
2=SUBSPACE ITERATION (BEST FOR LARGE PROBLEMS)
1
GEOMETRY DATA CHECK
NO ENTER 0
YES ENTER 3
0
TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0
1

WHAT IS THE LINE SPEED?
9600

IDENTIFY TERMINAL TYPE ACCORDING TO RESOLUTION,
CURSOR AND COLOUR CAPABILITY:
ENTER 0 FOR TEKTRONIX 4006 OR EQUAL (LOW RES/NO CURS/NO COL)
    1 FOR TEKTRONIX 401* OR EQUAL (LOW RES/CURSORS/NO COL)
    2 FOR TEKTRONIX 4014/15 (HI RES/CURSORS/NO COL)
    3 FOR TEKTRONIX 4113 (COLOUR):
2

IDENTIFY TERMINAL TYPE ACCORDING TO DIALOG CAPABILITY:
ENTER 0 NO DIALOG AREA
    1 DIALOG AREA

0
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING
          FINITE ELEMENT MODELS

SPECIFY LENGTH UNITS USED IN THIS ANALYSIS;
(FOR UNITS:  NIL IN. FT. MM.  M.
   ENTER:  0  1  2  3  4 ):
1
SPECIFY FORCE UNITS USED IN THIS ANALYSIS;
(FOR UNITS:  NIL LBS.  KIPS.   N.   KN.   MN.
   ENTER:  0   1    2    3    4    5 ):
1
ENTER 0 FOR VIEWING VECTOR APPROACH
  OR 1 FOR FINITE ANGULAR ROTATIONS:
1
DO YOU WISH TO USE DEFAULT PLOTTING  SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
DEFAULT VALUES NOW BEING SET ......
ENTER COMMAND STRING
```

VIEW
* VIEW / ELEMENT / B.C. SPECIFICATIONS *

ENTER ROTATIONS ABOUT BODY-FIXED AXES Z, Y & X
AND PLOT REDUCING FACTOR (PERCENT):
10 45 10 10
ENTER COMMAND STRING

PLOT

AFTER PLOTTING USE :
   C - TO DISPLAY COORDINATES OF SELECTED NODES
   L - TO LABEL NODES WITH CURSOR
   W - TO WINDOW
   R - TO RECOVER ORGINAL
PRESS "RETURN" TO PLOT

The resulting plot is shown in Figure 8.1.

ENTER COMMAND STRING

STOP

DEFINE FULL CYLINDER BOUNDARY CONSTRAINTS
POSITIVE DEFINITE SYSTEM CONSTRAINED AT ENDCAPS=3
POSITIVE DEFINITE SYSTEM CONSTAINED AT END CAPS AND MAX DIA=4
UNCONSTRAINED MODEL=5
BOUNDARY CONDITIONS WITH VASTBC AND SCREEN CURSOR=6
5

TO PLOT BOUNDARY CONDITIONS ENTER 2
TO CONTINUE ENTER 0
0
IS THE EFFECT OF THE SURROUNDING WATER TO BE CONSIDERED?
YES = 1 , NO = 0
1
LUMPED MASS CAN BE ENTERED IN TWO FORMS
MASS AND DISTANCE FROM FORWARD PERPENDICULAR
AND OR MASS AND THE NODE TO WHICH IT IS ATTACHED
(THE MASS,WHEN INPUT WITH THE DISTANCE IS DISTRIBUTED AMONG
THE ADJACENT NODES

ENTER THE NUMBER OF LUMPED MASSES LOCATED BY THEIR DISTANCE
FROM FORWARD PERPENDICULAR
2
ENTER THE DISTANCE AND THE LUMPED MASS 1
600 1000
ENTER THE DISTANCE AND THE LUMPED MASS 2
1800 2000
ENTER NUMBER OF NODES WHERE LUMPED MASSES ARE TO BE ADDED. (MAX 300)
1

ENTER THE NODE NUMBER AND THE SIX COMPONENTS OF

```
LUMPED MASS
ROTATIONAL MASSES ARE GENERALLY CONSIDERED TO BE 0
ENTER LAST MASS DATA
100 1000 1000 1000 0 0 0

    LUMPED MASSES
   NODE         MASSES
    49  100   1000.00   1000.00   1000.00     0.00     0.00     0.00
   ENTER 1 TO CONTINUE
1

IS THERE AN ERROR IN MASS DATA
IF YES ENTER LINE NUMBER
IF NO ENTER ZERO
0

TO PLOT LUMPED MASS ON FEM MODEL ENTER 1
TO CONTINUE ENTER 0
1
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING
          FINITE ELEMENT MODELS


DO YOU WISH TO USE DEFAULT PLOTTING  SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
DEFAULT VALUES NOW BEING SET ......
ENTER COMMAND STRING

VIEW
* VIEW / ELEMENT / B.C. SPECIFICATIONS *

ENTER ROTATIONS ABOUT BODY-FIXED AXES Z, Y & X
AND PLOT REDUCING FACTOR (PERCENT):
10 10 10 10

ENTER COMMAND STRING

LMAS
DO YOU WANT THE LUMPED MASSES INDICATED? (0=NO):
1
DO YOU WANT THE L.M. NODES NUMBERED? (0=NO):
0
ENTER COMMAND STRING

PLOT

 AFTER PLOTTING USE :
   C - TO DISPLAY COORDINATES OF SELECTED NODES
   L - TO LABEL NODES WITH CURSOR
   W - TO WINDOW
```

```
   R - TO RECOVER ORGINAL
 PRESS "RETURN" TO PLOT
```

The resulting plot is shown in Figure 8.2.

```
ENTER COMMAND STRING

STOP

TO PLOT MASS DIAGRAM ENTER 1
TO CONTINUE ENTER 0
1
CHOOSE FROM FOLLOWING PLOTTING OPTIONS
TO PLOT BAR CHART ENTER 1
TO PLOT AS STEPPED DATA ENTER 2
TO FINISH PLOTTING ENTER 0
1
```

The resulting plots are shown in Figures 8.3 and 8.4.

```
CHOOSE FROM FOLLOWING PLOTTING OPTIONS
TO PLOT BAR CHART ENTER 1
TO PLOT AS STEPPED DATA ENTER 2
TO FINISH PLOTTING ENTER 0
0
DO YOU WISH TO INSPECT MASS DATA FILE
YES=1
NO=0
0

IS PRINTOUT OF EIGENVECTORS REQUIRED
 YES ENTER 1
 NO ENTER 0
1
NATURAL FREQUENCY ANALYSIS

ENTER FIRST AND LAST MODE NUMBER TO BE COMPUTED
1 12
YOU HAVE CHOSEN MODE   1 TO MODE  12 TO BE CALCULATED.
ARE THE MODES CORRECT ?
YES=1
NO=0
1

DEFAULT VALUE OF ITERATIONS FOR EIGEN SOLUTION=20
IF NUMBER OF ITERATIONS SATISFACTORY ENTER 0
ENTER NEW VALUE IF LARGER VALUE REQUIRED
0
ITERATION TOLERANCE CURRENTLY SET TO 0.100E-02
IF TOLERANCE SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0
TOLERANCE FOR STURM SEQUENCE CHECK FOR MISSING EIGENVALUES
SET AT  0.01000 IF TOLERANCE SATISFACTORY ENTER 0
```

```
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0

TO PLOT ADDED MASS MODEL
ENTER 1 TO PLOT
   0 TO CONTINUE
1
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING
          FINITE ELEMENT MODELS

DO YOU WISH TO USE DEFAULT PLOTTING  SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
DEFAULT VALUES NOW BEING SET ......

ENTER COMMAND STRING

PLOT

 AFTER PLOTTING USE :
   C - TO DISPLAY COORDINATES OF SELECTED NODES
   L - TO LABEL NODES WITH CURSOR
   W - TO WINDOW
   R - TO RECOVER ORGINAL
 PRESS "RETURN" TO PLOT
```

The resulting plot is shown in Figure 8.5.

```
ENTER COMMAND STRING

STOP
LINE PRINTER OUTPUT IS ON FILE RBOAT.LPR
OTHER DATA OUTPUT:
FLUID MODEL DATA FILE RBOAT.AMD
PRESSURE HULL GEOMETRY FILE RBOAT.SBH
VAST GEOMETRY FILE RBOAT.GOM
VAST BOUNDRY CONDITION FILE RBOAT.SMD
LUMPED MASS FILE RBOAT.MMD
```

8.2 Stepped Hull Model

```
RUN SUBHUL
INPUT A 5 CHARACTER DATA FILE NAME
STPHL
NEW FILE NAME
TO CONTINUE = 0
TO CHANGE NAME = 1
0
SAIL TO BE INCLUDED
YES = 0
NO = 1
```

```
1
SAIL IS NOT INCLUDED WITH PRESSURE HULL
ENTER 0 TO CONTINUE
   1 TO CHANGE
0
ENTER UP TO 90 CHARACTER TITLE
TEST OF SUBHUL AXISYMMETRIC STEPPED HULL MODEL

TITLE: TEST OF SUBHUL AXISYMMETRIC STEPPED HULL MODEL
ENTER 0 TO CONTINUE
   1 TO CHANGE
0
ENTER UNITS FOR DIMENSIONS
0 = NIL
1 = IN.
2 = FT.
3 = MM.
4 = M.
1
ENTER UNITS OF FORCE
0 = NIL
1 = LBS
2 = KIPS
3 = N.
4 = KN.
5 = MN.
1
UNITS CHOSEN FOR DIMENSION AND FORCE = IN.  AND LBS
CORRECT  YES=0  NO=1
1
ENTER UNITS FOR DIMENSIONS
0 = NIL
1 = IN.
2 = FT.
3 = MM.
4 = M.
1
ENTER UNITS OF FORCE
0 = NIL
1 = LBS.
2 = KIPS.
3 = N.
4 = KN.
5 = MN.
1
UNITS CHOSEN FOR DIMENSION AND FORCE = IN.  AND LBS
CORRECT  YES=0  NO=1
-   0

CHOOSE PRESSURE HULL FORM
CONVENTIONAL FLAT DECK FORM ENTER 0
AXISYMMETRIC HULL FORM ENTER 1
STEPPED AXISYMMETRIC HULL FORM ENTER 2
2
```

ENTER THE NO OF DIA REQUIRED TO DESCRIBE THE PRESS HULL
10
ENTER THE DIAMETERS STARTING AT BOW
DIAMETER 1
100
DIAMETER 2
100
DIAMETER 3
225
DIAMETER 4
237
DIAMETER 5
200
DIAMETER 6
100
DIAMETER 7
100
DIAMETER 8
150
DIAMETER 9
100
LAST DIAMETER 10
75
ENTER DIAMETER LOCATIONS AS DIST FROM FWD PERP
DIST 1
0
DIST 2
200
DIST 3
225
DIST 4
600
DIST 5
900
DIST 6
1000
DIST 7
1150
DIST 8
1200
DIST 9
1500
LAST DIST 10
1650

DIAMETERS AND DISTANCES CHOSEN

1	100.00	0.00
2	100.00	200.00
3	225.00	225.00
4	237.00	600.00
5	200.00	900.00
6	100.00	1000.00
7	100.00	1150.00
8	150.00	1200.00

```
 9    100.00    1500.00
10     75.00    1650.00
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
3
LINE OF DATA WITH SUSPECTED ERROR
   225.000    225.000
IS THIS LINE CORRECT ENTER
YES = 1
NO = 0
0
ENTER CORRECT LINE OF DATA
225 300

DIAMETERS AND DISTANCES CHOSEN
 1    100.00       0.00
 2    100.00     200.00
 3    225.00     300.00
 4    237.00     600.00
 5    200.00     900.00
 6    100.00    1000.00
 7    100.00    1150.00
 8    150.00    1200.00
 9    100.00    1500.00
10     75.00    1650.00
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
0
ENTER  9 PLATE THICKNESSES ONE FOR EACH TWO DIA
BETWEEN DIAMETERS      100.00     100.00
1
BETWEEN DIAMETERS      100.00     225.00
1
BETWEEN DIAMETERS      225.00     237.00
1
BETWEEN DIAMETERS      237.00     200.00
1
BETWEEN DIAMETERS      200.00     100.00
1
BETWEEN DIAMETERS      100.00     100.00
1
BETWEEN DIAMETERS      100.00     150.00
1
BETWEEN DIAMETERS      150.00     100.00
1
BETWEEN DIAMETERS      100.00      75.00
1
 THICKNESS   BETWEEN DIAMETERS
    1.00         100.00  100.00
    1.00         100.00  225.00
    1.00         225.00  237.00
    1.00         237.00  200.00
```

```
    1.00        200.00  100.00
    1.00        100.00  100.00
    1.00        100.00  150.00
    1.00        150.00  100.00
    1.00        100.00   75.00
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
0
ENTER SPHERICAL RADII OF BOW AND STERN DOMED ENDCAPS
60 45
1  SPHERICAL RADIUS OF BOW DOMED ENDCAP    60.000
2  SPHERICAL RADIUS OF STERN DOMED ENDCAP    45.000
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
0
ENTER BOW ENDCAP THICKNESS
1
ENTER STERN ENDCAP THICKNESS
1
    1.00     1.00 BOW ENDCAP AND STERN ENDCAP THICKNESS
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
0
IS A PATRAN SESSION FILE TO BE CREATED
YES = 0
NO = 1
1
ENTER NO OF BULKHEADS
3
ENTER THE BULKHEAD LOCATIONS AS DISTANCE FROM BOW
ENTER BULKHD   1 DIST
300
ENTER BULKHD   2 DIST
900
ENTER BULKHD   3 DIST
1200
NO  DISTANCE
 1     300.000
 2     900.000
 3    1200.000
IS BULKHEAD DATA CORRECT   YES = 0  NO = 1
0
ENTER 3 BULKHEAD PLATE THICKNESSES
BULKHD   1 THICKNESS
1
BULKHD   2 THICKNESS
1
BULKHD   3 THICKNESS
1
NO. BULKHD THICKNESS
  1     1.000
```

2 1.000
3 1.000
IS BULKHEAD DATA CORRECT YES = 0 NO = 1
0
ENTER NUMBER OF CIRCUMFERENTIAL ELEMENTS (MAX. 16)
6
FOR HALF CYLINDER MODEL ENTER 1
FULL CYLINDER MODEL ENTER 2
2

ARE SHELL RING STIFFENERS REQUIRED
YES=0
NO=1
0
CHOOSE METHOD FOR DEFINING RING STIFFENER SIZE
1 = CROSSECTION PROPERTIES
2 = T SECTION DIMENSIONS
2
FOR EACH DIAMETER AND DISTANCE ENTER THE FLANGE WIDTH AND THICKNESS AND WEB DEPTH AND THICKNESS
NO. DIAMETER DISTANCE
1 100.000 0.000
5 .375 10 .375
NO. DIAMETER DISTANCE
2 100.000 200.000
5 .375 10 .375
NO. DIAMETER DISTANCE
3 225.000 300.000
8 .5 15 .375
NO. DIAMETER DISTANCE
4 237.000 600.000
8 .5 15 .375
NO. DIAMETER DISTANCE
5 200.000 900.000
8 .5 15 .375
NO. DIAMETER DISTANCE
6 100.000 1000.000
5 .375 10 .375
NO. DIAMETER DISTANCE
7 100.000 1150.000
5 .375 10 .375
NO. DIAMETER DISTANCE
8 150.000 1200.000
6 .5 12 .375
NO. DIAMETER DISTANCE
9 100.000 1500.000
5 .375 10 .375
NO. DIAMETER DISTANCE
10 75.000 1650.000
4 .375 9 .375

NO.	FLANGE	THICK	WEB	THICK	WIDTH	DEPTH	NEUT AXIS
1	5.00	0.38	10.00	0.38	0.48	11.77	6.73
2	5.00	0.38	10.00	0.38	0.48	11.77	6.73
3	8.00	0.50	15.00	0.38	0.55	17.51	10.72

4	8.00	0.50	15.00	0.38	0.55	17.51	10.72
5	8.00	0.50	15.00	0.38	0.55	17.51	10.72
6	5.00	0.38	10.00	0.38	0.48	11.77	6.73
7	5.00	0.38	10.00	0.38	0.48	11.77	6.73
8	6.00	0.50	2.00	0.38	0.53	14.11	8.50
9	4.00	0.38	9.00	0.38	0.46	10.60	5.94

ARE THE VALUES CORRECT
YES=0
NO=1
0
CONVERT NEUTRAL AXIS DIMENSIONS TO ECCENTRICITY BY ENTERING SHELL THICKNESS
AT FOLLOWING DIAMETERS AND DISTANCES (NEGATIVE VALUES PLACE STIFFENER ON INSIDE

NO	DIAMETER	DISTANCE
1	100.000	0.000
2	100.000	200.000
3	225.000	300.000
4	237.000	600.000
5	200.000	900.000
6	100.000	1000.000
7	100.000	1150.000
8	150.000	1200.000
9	100.000	1500.000
10	75.000	1650.000

-1 -1 -1 -1 -1 -1 -1 -1 -1

ARE THE VALUES CORRECT
YES=0
NO=1
1
CONVERT NEUTRAL AXIS DIMENSIONS TO ECCENTRICITY BY ENTERING SHELL THICKNESS
AT FOLLOWING DIAMETERS AND DISTANCES (NEGATIVE VALUES PLACE STIFFENER ON INSIDE

NO	DIAMETER	DISTANCE
1	100.000	0.000
2	100.000	200.000
3	225.000	300.000
4	237.000	600.000
5	200.000	900.000
6	100.000	1000.000
7	100.000	1150.000
8	150.000	1200.000
9	100.000	1500.000
10	75.000	1650.000

-1 -1 -1 -1 -1 -1 -1 -1 -1-1
ARE THE VALUES CORRECT
YES=0
NO=1
0
FOR EACH SPACE AND DIST LISTED BELOW
ENTER THE NUMBER OF RING STIFFENERS BETWEEN

NO.	SPACING	DISTANCE
1	200.000	200.000
2	100.000	300.000
3	300.000	600.000
4	300.000	900.000
5	100.000	1000.000
6	150.000	1150.000
7	50.000	1200.000
8	300.000	1500.000
9	150.000	1650.000

2 1 3 3 1 2 1 3 2
ARE THE VALUES CORRECT
YES=0
NO=1
0
ARE ALL RING STIFFENERS BETWEEN THE SAME SIZE
YES = 0
NO = 1
0
ENTER STIFFENER FLANGE WIDTH AND THICKNESS AND WEB DEPTH AND THICKNESS
6 .5 10 .375
ARE THE VALUES CORRECT
YES=0
NO=1
0
ENTER THE PLATE THICKNESS FOR THE FOLLOWING SPACES
(NEGATIVE VALUES PLACES STIFFENERS ON THE INSIDE OF HULL)

NO	SPACING	DISTANCE
1	200.000	0.000
2	100.000	200.000
3	300.000	300.000
4	300.000	600.000
5	100.000	900.000
6	150.000	1000.000
7	50.000	1150.000
8	300.000	1200.000
9	150.000	1500.000

-1 -1 -1 -1 -1 -1 -1 -1 -1
ARE THE VALUES CORRECT
YES=0
NO=1
0
EQUIVALENT CURVED BEAM CROSSECTION

SPACE	BEAM WIDTH	BEAM DEPTH	ECCENTRICITY
200.00	0.58	11.72	-8.33
100.00	0.58	11.72	-8.33
300.00	0.58	11.72	-8.33
300.00	0.58	11.72	-8.33
100.00	0.58	11.72	-8.33
150.00	0.58	11.72	-8.33
50.00	0.58	11.72	-8.33
300.00	0.58	11.72	-8.33
150.00	0.58	11.72	-8.33

```
ARE THE VALUES CORRECT
YES=0
NO=1
0
ENTER THE NUMBER OF SHELL ELEMENTS BETWEEN RING BEAMS
1
ARE THE ELEMENTS BETWEEN BEAMS= 1 CORRECT
YES=0
NO=1
0
ENTER THE NUMBER OF AXIAL ELEMENTS IN DOMED END CAPS
2
NUMBER OF SHELL NODES= 570
NUMBER OF SHELL DEGREES OF FREEDOM=2850
IF NUMBER DEGREES OF FREEDOM TOO HIGH ENTER 1 TO RESTART
ENTER 0 TO CONTINUE
0
MATERIAL PROPERTIES ARE SAME THROUGHOUT STRUCTURE
YES = 0
 NO = 1
0
ENTER YOUNGS MODULUS-POISSONS RATIO-DENSITY FOR STRUCTURE
30000000 .3 .000733
GEOMETRY AND ELEMENT GENERATION COMPLETE

TO END AND PRINT GEOMETRY AND ELEMENT DATA ENTER 1
 TO EXAMINE RING STIFFENER ARRANGEMENT ENTER 2
 TO PROCEED AND GENERATE A VAST ANALYSIS FILE ENTER 3
2
DO YOU WISH TO EXAMINE RING STIFFENER SIZE AND LOCATION
YES = 0   NO = 1
0
TO LIST STIFFENERS = 1
TO PLOT STIFFENERS = 2
TO STOP = 3
TO CONTINUE =0
2

WHAT IS THE LINE SPEED?
9600

IDENTIFY TERMINAL TYPE ACCORDING TO RESOLUTION,
CURSOR AND COLOUR CAPABILITY:
ENTER 0 FOR TEKTRONIX 4006 OR EQUAL (LOW RES/NO CURS/NO COL)
    1 FOR TEKTRONIX 401* OR EQUAL (LOW RES/CURSORS/NO COL)
    2 FOR TEKTRONIX 4014/15 (HI RES/CURSORS/NO COL)
    3 FOR TEKTRONIX 4113 (COLOUR):
2

IDENTIFY TERMINAL TYPE ACCORDING TO DIALOG CAPABILITY:
ENTER 0 NO DIALOG AREA
    1 DIALOG AREA

0
```

The resulting plot is shown in Figure 8.6.

```
TO LIST STIFFENERS = 1
TO PLOT STIFFENERS = 2
TO STOP = 3
TO CONTINUE =0
0

IS FLUID INTERACTION TO BE CONSIDERED
YES ENTER 0
NO  ENTER 1
0
ENTER FLUID METHOD TO BE USED
1 = FLUID ELEMENT METHOD
2 = SURFACE PANEL METHOD
1
ENTER NUMBER OF FLUID LAYERS  ( MAX = 5 )
3
ENTER TYPE OF ANALYSIS

1 = STATIC
2 = BUCKLING RUN #1 (TO GET INITIAL STRESSES)
3 = NATURAL FREQUENCY
5 = BUCKLING RUN #2(CRITICAL LOAD)
6 = NATURAL FREQUENCY RUN #1(HULL UNDER PRESS)
7 = NATURAL FREQUENCY RUN #2(HULL UNDER PRESS)
3
IS BANDWIDTH REDUCTION REQUIRED

YES=0
NO=1
0
ENTER TYPE OF NATURAL FREQUENCY CALCULATION
1=DIRECT ITERATION
2=SUBSPACE ITERATION (BEST FOR LARGE PROBLEMS)
1
GEOMETRY DATA CHECK
NO ENTER 0
YES ENTER 3
0
TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0
1
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING
          FINITE ELEMENT MODELS

SPECIFY LENGTH UNITS USED IN THIS ANALYSIS;
(FOR UNITS:  NIL IN. FT. MM.  M.
   ENTER:  0  1  2  3  4 ):
1
```

SPECIFY FORCE UNITS USED IN THIS ANALYSIS;
(FOR UNITS: NIL LBS. KIPS.   N.   KN.   MN.
   ENTER: 0   1   2   3   4   5):
1
ENTER 0 FOR VIEWING VECTOR APPROACH
  OR 1 FOR FINITE ANGULAR ROTATIONS:
1
DO YOU WISH TO USE DEFAULT PLOTTING SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1
DEFAULT VALUES NOW BEING SET ......

ENTER COMMAND STRING

VIEW
* VIEW / ELEMENT / B.C. SPECIFICATIONS *

ENTER ROTATIONS ABOUT BODY-FIXED AXES Z, Y & X
AND PLOT REDUCING FACTOR (PERCENT):
10 30 10 10
ENTER COMMAND STRING

PLOT

AFTER PLOTTING USE :
   C - TO DISPLAY COORDINATES OF SELECTED NODES
   L - TO LABEL NODES WITH CURSOR
   W - TO WINDOW
   R - TO RECOVER ORGINAL
PRESS "RETURN" TO PLOT

The resulting plot is shown in Figure 8.7.

ENTER COMMAND STRING

STOP

DEFINE FULL CYLINDER MODEL BOUNDARY CONSTRAINTS
POSITIVE DEFINITE SYSTEM CONSTRAINED AT ENDCAPS=3
POSITIVE DEFINITE SYSTEM CONSTAINED AT END CAPS AND MAX DIA=4
UNCONSTRAINED MODEL=5
BOUNDARY CONDITIONS WITH VASTBC AND SCREEN CURSOR=6
5

TO PLOT BOUNDARY CONDITIONS ENTER 2
TO CONTINUE ENTER 0
0
IS THE EFFECT OF THE SURROUNDING WATER TO BE CONSIDERED?
YES = 1 , NO = 0
1
LUMPED MASS CAN BE ENTERED IN TWO FORMS
MASS AND DISTANCE FROM FORWARD PERPENDICULAR
AND OR MASS AND THE NODE TO WHICH IT IS ATTACHED
(THE MASS,WHEN INPUT WITH THE DISTANCE IS DISTRIBUTED AMONG

THE ADJACENT NODES

ENTER THE NUMBER OF LUMPED MASSES LOCATED BY THEIR DISTANCE
FROM FORWARD PERPENDICULAR
0
ENTER NUMBER OF NODES WHERE LUMPED MASSES ARE TO BE ADDED. (MAX 300)
0

IS PRINTOUT OF EIGENVECTORS REQUIRED
YES ENTER 1
NO ENTER 0
0
NATURAL FREQUENCY ANALYSIS

ENTER FIRST AND LAST MODE NUMBER TO BE COMPUTED
1 12
YOU HAVE CHOSEN MODE 1 TO MODE 12 TO BE CALCULATED.
ARE THE MODES CORRECT ?
YES=1
NO=0
1

DEFAULT VALUE OF ITERATIONS FOR EIGEN SOLUTION=20
IF NUMBER OF ITERATIONS SATISFACTORY ENTER 0
ENTER NEW VALUE IF LARGER VALUE REQUIRED
0
ITERATION TOLERANCE CURRENTLY SET TO 0.100E-02
IF TOLERANCE SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0
TOLERANCE FOR STURM SEQUENCE CHECK FOR MISSING EIGENVALUES
SET AT 0.01000 IF TOLERANCE SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0

TO PLOT ADDED MASS MODEL
ENTER 1 TO PLOT
0 TO CONTINUE
1
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1
PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING
FINITE ELEMENT MODELS

DO YOU WISH TO USE DEFAULT PLOTTING SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1
DEFAULT VALUES NOW BEING SET ......

ENTER COMMAND STRING

PLOT

```
AFTER PLOTTING USE :
  C - TO DISPLAY COORDINATES OF SELECTED NODES
  L - TO LABEL NODES WITH CURSOR
  W - TO WINDOW
  R - TO RECOVER ORGINAL
PRESS "RETURN" TO PLOT
```

The resulting plot is shown in Figure 8.8.

```
ENTER COMMAND STRING

STOP
LINE PRINTER OUTPUT IS ON FILE STPHL.LPR
OTHER DATA OUTPUT:
FLUID MODEL DATA FILE STPHL.AMD
PRESSURE HULL GEOMETRY FILE STPHL.SBH
VAST GEOMETRY FILE STPHL.GOM
VAST BOUNDRY CONDITION FILE STPHL.SMD
LUMPED MASS FILE STPHL.MMD
```

8.3 Smooth Outline Model

```
RUN SUBHUL
INPUT A 5 CHARACTER DATA FILE NAME
FBOAT
NEW FILE NAME
TO CONTINUE = 0

TO CHANGE NAME = 1
0
SAIL TO BE INCLUDED
YES = 0
NO = 1
1
SAIL IS NOT INCLUDED WITH PRESSURE HULL
ENTER 0 TO CONTINUE
    1 TO CHANGE
0
ENTER UP TO 90 CHARACTER TITLE
TEST OF AXISYMMETRIC MODEL

TITLE: TEST OF AXISYMMETRIC MODEL
ENTER 0 TO CONTINUE
    1 TO CHANGE
0
ENTER UNITS FOR DIMENSIONS
0 = NIL
1 = IN.
2 = FT.
3 = MM.
4 = M.
3
ENTER UNITS OF FORCE
0 = NIL
```

1 = LB.
2 = KIPS.
3 = N.
4 = KN.
5 = MN.
3
UNITS CHOSEN FOR DIMENSION AND FORCE = mm. AND N
CORRECT YES=0 NO=1
0

CHOOSE PRESSURE HULL FORM
CONVENTIONAL FLAT DECK FORM ENTER 0
AXISYMMETRIC HULL FORM ENTER 1
STEPPED AXISYMMETRIC HULL FORM ENTER 2
1
ENTER THE NO OF DIA REQUIRED TO DESCRIBE THE PRESS HULL
10
ENTER THE DIAMETERS STARTING AT BOW
DIAMETER 1
4900
DIAMETER 2
6400
DIAMETER 3
7400
DIAMETER 4
7600
DIAMETER 5
7600
DIAMETER 6
7600
DIAMETER 7
7340
DIAMETER 8
6400
DIAMETER 9
4220
LAST DIAMETER 10
1370
ENTER DIAMETER LOCATIONS AS DIST FROM FWD PERP
DIST 1
0
DIST 2
2000
DIST 3
4700
DIST 4
10500
DIST 5
31800
DIST 6
52500
DIST 7
58500
DIST 8

```
64500
DIST  9
70500
LAST DIST  10
76500

DIAMETERS AND DISTANCES CHOSEN
  1      4900.00       0.00
  2      6400.00    2000.00
  3      7400.00    4700.00
  4      7600.00   10500.00
  5      7600.00   31800.00
  6      7600.00   52500.00
  7      7340.00   58500.00
  8      6400.00   64500.00
  9      4220.00   70500.00
 10      1370.00   76500.00
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
0
ENTER  9 PLATE THICKNESSES ONE FOR EACH TWO DIA
BETWEEN DIAMETERS      4900.00     6400.00
1
BETWEEN DIAMETERS      6400.00     7400.00
1
BETWEEN DIAMETERS      7400.00     7600.00
1
BETWEEN DIAMETERS      7600.00     7600.00
1
BETWEEN DIAMETERS      7600.00     7600.00
1
BETWEEN DIAMETERS      7600.00     7340.00
1
BETWEEN DIAMETERS      7340.00     6400.00
1
BETWEEN DIAMETERS      6400.00     4220.00
1
BETWEEN DIAMETERS      4220.00     1370.00
1
 THICKNESS   BETWEEN DIAMETERS
    1.00        4900.00  6400.00
    1.00        6400.00  7400.00
    1.00        7400.00  7600.00
    1.00        7600.00  7600.00
    1.00        7600.00  7600.00
    1.00        7600.00  7340.00
    1.00        7340.00  6400.00
    1.00        6400.00  4220.00
    1.00        4220.00  1370.00
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
0
```

ENTER SPHERICAL RADII OF BOW AND STERN DOMED ENDCAPS
2500 800
1 SPHERICAL RADIUS OF BOW DOMED ENDCAP 2500.000
2 SPHERICAL RADIUS OF STERN DOMED ENDCAP 800.000
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
ENTER BOW ENDCAP THICKNESS
1
ENTER STERN ENDCAP THICKNESS
1
1.00 1.00 BOW ENDCAP AND STERN ENDCAP THICKNESS
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
IS A PATRAN SESSION FILE TO BE CREATED
YES = 0
NO = 1
1
ENTER NO OF BULKHEADS
2
ENTER THE BULKHEAD LOCATIONS AS DISTANCE FROM BOW
ENTER BULKHD 1 DIST
10500
ENTER BULKHD 2 DIST
64500
NO DISTANCE
1 10500.000
2 64500.000
IS BULKHEAD DATA CORRECT YES = 0 NO = 1
0
ENTER 2 BULKHEAD PLATE THICKNESSES
BULKHD 1 THICKNESS
1
BULKHD 2 THICKNESS
1
NO. BULKHD THICKNESS
1 1.000
2 1.000
IS BULKHEAD DATA CORRECT YES = 0 NO = 1
0
ENTER NUMBER OF CIRCUMFERENTIAL ELEMENTS (MAX. 16)
6
FOR HALF CYLINDER MODEL ENTER 1
FULL CYLINDER MODEL ENTER 2
2

ARE SHELL RING STIFFENERS REQUIRED
YES=0
NO=1
0
CHOOSE METHOD FOR DEFINING RING STIFFENER SIZE

1 = CROSSECTION PROPERTIES
2 = T SECTION DIMENSIONS
2
FOR EACH DIAMETER AND DISTANCE ENTER THE FLANGE WIDTH AND THICKNESS AND WEB DEPTH AND THICKNESS
NO. DIAMETER DISTANCE
1 4900.000 0.000
125 12 250 10
NO. DIAMETER DISTANCE
2 6400.000 2000.000
125 12 300 10
NO. DIAMETER DISTANCE
3 7400.000 4700.000
2203 12 381 10
NO. DIAMETER DISTANCE
4 7600.000 10500.000
203 12 381 10
NO. DIAMETER DISTANCE
5 7600.000 31800.000
203 12 381 10
NO. DIAMETER DISTANCE
6 7600.000 52500.000
203 12 381 10
NO. DIAMETER DISTANCE
7 7340.000 58500.000
203 12 381 10
NO. DIAMETER DISTANCE
8 6400.000 64500.000
125 12 300 10
NO. DIAMETER DISTANCE
9 4220.000 70500.000
125 12 250 10
NO. DIAMETER DISTANCE
10 1370.000 76500.000
100 12 200 8

NO.	FLANGE	THICK	WEB	THICK	WIDTH	DEPTH	NEUT AXIS
1	125.00	12.00	250.00	10.00	13.53	295.60	174.13
2	125.00	12.00	300.00	10.00	12.73	353.47	202.00
3	2203.00	12.00	381.00	10.00	114.79	263.49	362.25
4	203.00	12.00	381.00	10.00	14.01	445.91	267.14
5	203.00	12.00	381.00	10.00	14.01	445.91	267.14
6	203.00	12.00	381.00	10.00	14.01	445.91	267.14
7	203.00	12.00	381.00	10.00	14.01	445.91	267.14
8	125.00	12.00	300.00	10.00	12.73	353.47	202.00
9	125.00	12.00	250.00	10.00	13.53	295.60	174.13
10	100.00	12.00	200.00	8.00	11.84	236.51	145.43

ARE THE VALUES CORRECT
YES=0
NO=1
1
FOR EACH DIAMETER AND DISTANCE ENTER THE FLANGE WIDTH AND THICKNESS AND WEB DEPTH AND THICKNESS
NO. DIAMETER DISTANCE
1 4900.000 0.000

125 12 250 10
NO. DIAMETER DISTANCE
2 6400.000 2000.000
125 12 300 10
NO. DIAMETER DISTANCE
3 7400.000 4700.000
203 12 381 10
NO. DIAMETER DISTANCE
4 7600.000 10500.000
203 12 381 10
NO. DIAMETER DISTANCE
5 7600.000 31800.000
203 12 381 10
NO. DIAMETER DISTANCE
6 7600.000 52500.000
203 12 381 10
NO. DIAMETER DISTANCE
7 7340.000 58500.000
203 12 381 10
NO. DIAMETER DISTANCE
8 6400.000 64500.000
125 12 300 10
NO. DIAMETER DISTANCE
9 4220.000 70500.000
125 12 120 10
NO. DIAMETER DISTANCE
10 1370.000 76500.000
100 12 200 8

NO.	FLANGE	THICK	WEB	THICK	WIDTH	DEPTH	NEUT AXIS
1	125.00	12.00	250.00	10.00	13.53	295.60	174.13
2	125.00	12.00	300.00	10.00	12.73	353.47	202.00
3	203.00	12.00	381.00	10.00	14.01	445.91	267.14
4	203.00	12.00	381.00	10.00	14.01	445.91	267.14
5	203.00	12.00	381.00	10.00	14.01	445.91	267.14
6	203.00	12.00	381.00	10.00	14.01	445.91	267.14
7	203.00	12.00	381.00	10.00	14.01	445.91	267.14
8	125.00	12.00	300.00	10.00	12.73	353.47	202.00
9	125.00	12.00	120.00	10.00	19.39	139.24	96.67
10	100.00	12.00	200.00	8.00	11.84	236.51	145.43

ARE THE VALUES CORRECT
YES=0
NO=1
0
CONVERT NEUTRAL AXIS DIMENSIONS TO ECCENTRICITY BY ENTERING SHELL THICKNESS
AT FOLLOWING DIAMETERS AND DISTANCES (NEGATIVE VALUES PLACE STIFFENER ON INSIDE

NO	DIAMETER	DISTANCE
1	4900.000	0.000
2	6400.000	2000.000
3	7400.000	4700.000
4	7600.000	10500.000
5	7600.000	31800.000
6	7600.000	52500.000

```
 7   7340.000  58500.000
 8   6400.000  64500.000
 9   4220.000  70500.000
10    1370.000  76500.000
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
ARE THE VALUES CORRECT
YES=0
NO=1
0
FOR EACH SPACE AND DIST LISTED BELOW
ENTER THE NUMBER OF RING STIFFENERS BETWEEN

NO.     SPACING    DISTANCE
 1        2000.000      2000.000
 2        2700.000      4700.000
 3        5800.000      10500.000
 4        21300.000     31800.000
 5        20700.000     52500.000
 6        6000.000      58500.000
 7        6000.000      64500.000
 8        6000.000      70500.000
 9        6000.000      76500.000
2 2 3 5 5 3 3 3 3
ARE THE VALUES CORRECT
YES=0
NO=1
0
ARE ALL RING STIFFENERS BETWEEN THE SAME SIZE
YES = 0
NO = 1
0
ENTER STIFFENER FLANGE WIDTH AND THICKNESS AND WEB DEPTH AND
THICKNESS
125 12 250 10
ARE THE VALUES CORRECT
YES=0
NO=1
0
ENTER THE PLATE THICKNESS FOR THE FOLLOWING SPACES
(NEGATIVE VALUES PLACES STIFFENERS ON THE INSIDE OF HULL)
NO    SPACING     DISTANCE
 1      2000.000      0.000
 2      2700.000     2000.000
 3      5800.000     4700.000
 4      21300.000    10500.000
 5      20700.000    31800.000
 6      6000.000     52500.000
 7      6000.000     58500.000
 8      6000.000     64500.000
 9      6000.000     70500.000
-1 -1 -1 -1 -1 -1 -1 -1 -1
ARE THE VALUES CORRECT
YES=0
NO=1
```

0
EQUIVALENT CURVED BEAM CROSSECTION

SPACE	BEAM WIDTH	BEAM DEPTH	ECCENTRICITY
2000.00	13.53	295.60	-175.13
2700.00	13.53	295.60	-175.13
5800.00	13.53	295.60	-175.13
21300.00	13.53	295.60	-175.13
20700.00	13.53	295.60	-175.13
6000.00	13.53	295.60	-175.13
6000.00	13.53	295.60	-175.13
6000.00	13.53	295.60	-175.13
6000.00	13.53	295.60	-175.13

ARE THE VALUES CORRECT
YES=0
NO=1
0

ENTER THE NUMBER OF SHELL ELEMENTS BETWEEN RING BEAMS
1
ARE THE ELEMENTS BETWEEN BEAMS= 1 CORRECT
YES=0
NO=1
1

ENTER THE NUMBER OF AXIAL ELEMENTS IN DOMED END CAPS
2
NUMBER OF SHELL NODES= 768
NUMBER OF SHELL DEGREES OF FREEDOM=3840
IF NUMBER DEGREES OF FREEDOM TOO HIGH ENTER 1 TO RESTART
ENTER 0 TO CONTINUE
0
MATERIAL PROPERTIES ARE SAME THROUGHOUT STRUCTURE
YES = 0
NO = 1
0
ENTER YOUNGS MODULUS-POISSONS RATIO-DENSITY FOR STRUCTURE
200000 .3 .000000073
GEOMETRY AND ELEMENT GENERATION COMPLETE

TO END AND PRINT GEOMETRY AND ELEMENT DATA ENTER 1
TO EXAMINE RING STIFFENER ARRANGEMENT ENTER 2
TO PROCEED AND GENERATE A VAST ANALYSIS FILE ENTER 3
2
DO YOU WISH TO EXAMINE RING STIFFENER SIZE AND LOCATION
YES = 0 NO = 1
0
TO LIST STIFFENERS = 1
TO PLOT STIFFENERS = 2
TO STOP = 3
TO CONTINUE =0
2

WHAT IS THE LINE SPEED?
9600

```
IDENTIFY TERMINAL TYPE ACCORDING TO RESOLUTION,
CURSOR AND COLOUR CAPABILITY:
ENTER 0 FOR TEKTRONIX 4006 OR EQUAL (LOW RES/NO CURS/NO COL)
    1 FOR TEKTRONIX 401* OR EQUAL (LOW RES/CURSORS/NO COL)
    2 FOR TEKTRONIX 4014/15 (HI RES/CURSORS/NO COL)
    3 FOR TEKTRONIX 4113 (COLOUR):
1

IDENTIFY TERMINAL TYPE ACCORDING TO DIALOG CAPABILITY:
ENTER 0 NO DIALOG AREA
    1 DIALOG AREA

0
```

The resulting plot is shown in Figure 8.9.

```
TO LIST STIFFENERS = 1
TO PLOT STIFFENERS = 2
TO STOP = 3
TO CONTINUE =0
0

IS FLUID INTERACTION TO BE CONSIDERED
YES ENTER 0
NO  ENTER 1
0
ENTER FLUID METHOD TO BE USED
1 = FLUID ELEMENT METHOD
2 = SURFACE PANEL METHOD
1
ENTER NUMBER OF FLUID LAYERS  ( MAX = 5 )
3
ENTER TYPE OF ANALYSIS

1 = STATIC
2 = BUCKLING RUN #1 (TO GET INITIAL STRESSES)
3 = NATURAL FREQUENCY
5 = BUCKLING RUN #2(CRITICAL LOAD)
6 = NATURAL FREQUENCY RUN #1(HULL UNDER PRESS)
7 = NATURAL FREQUENCY RUN #2(HULL UNDER PRESS)
3
IS BANDWIDTH REDUCTION REQUIRED

YES=0
NO=1
0
ENTER TYPE OF NATURAL FREQUENCY CALCULATION
1=DIRECT ITERATION
2=SUBSPACE ITERATION (BEST FOR LARGE PROBLEMS)
1
GEOMETRY DATA CHECK
NO ENTER 0
YES ENTER 3
```

```
0
TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0
1
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING
        FINITE ELEMENT MODELS

SPECIFY LENGTH UNITS USED IN THIS ANALYSIS;
(FOR UNITS:  NIL IN. FT. MM.  M.
   ENTER:  0  1  2  3  4 ):
1
SPECIFY FORCE UNITS USED IN THIS ANALYSIS;
(FOR UNITS:  NIL LBS.  KIPS.   N.   KN.   MN.
   ENTER:  0   1    2    3    4    5 ):
3
ENTER 0 FOR VIEWING VECTOR APPROACH
  OR 1 FOR FINITE ANGULAR ROTATIONS:
1
DO YOU WISH TO USE DEFAULT PLOTTING  SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
DEFAULT VALUES NOW BEING SET ......

ENTER COMMAND STRING

VIEW
* VIEW / ELEMENT / B.C. SPECIFICATIONS *

ENTER ROTATIONS ABOUT BODY-FIXED AXES Z, Y & X
AND PLOT REDUCING FACTOR (PERCENT):
10 10 10 10
ENTER COMMAND STRING

PLOT

 AFTER PLOTTING USE :
        C - TO DISPLAY COORDINATES OF SELECTED NODES
        L - TO LABEL NODES WITH CURSOR
        W - TO WINDOW
        R - TO RECOVER ORGINAL
        PRESS "RETURN" TO PLOT
```

The resulting plot is shown Figure 8.10.

```
ENTER COMMAND STRING

STOP

FULL CYLINDER POSITIVE DEFINITE MODEL=3
FULL CYLINDER UNCONSTRAINED MODEL=4
FULL CYLINDER BOUNDARY CONDITIONS WITH SCREEN CURSOR=5
```

4

TO PLOT BOUNDARY CONDITIONS ENTER 2
TO CONTINUE ENTER 0
0
IS THE EFFECT OF THE SURROUNDING WATER TO BE CONSIDERED?
YES = 1 , NO = 0
1
LUMPED MASS CAN BE ENTERED IN TWO FORMS
MASS AND DISTANCE FROM FORWARD PERPENDICULAR
AND OR MASS AND THE NODE TO WHICH IT IS ATTACHED
(THE MASS,WHEN INPUT WITH THE DISTANCE IS DISTRIBUTED AMONG
THE ADJACENT NODES

ENTER THE NUMBER OF LUMPED MASSES LOCATED BY THEIR DISTANCE
FROM FORWARD PERPENDICULAR
0
ENTER NUMBER OF NODES WHERE LUMPED MASSES ARE TO BE ADDED. (MAX 300)
0

IS PRINTOUT OF EIGENVECTORS REQUIRED
YES ENTER 1
NO ENTER 0
0
NATURAL FREQUENCY ANALYSIS

ENTER FIRST AND LAST MODE NUMBER TO BE COMPUTED
1 12
YOU HAVE CHOSEN MODE 1 TO MODE 12 TO BE CALCULATED.
ARE THE MODES CORRECT ?
YES=1
NO=0
1
DEFAULT VALUE OF ITERATIONS FOR EIGEN SOLUTION=20
IF NUMBER OF ITERATIONS SATISFACTORY ENTER 0
ENTER NEW VALUE IF LARGER VALUE REQUIRED
0
ITERATION TOLERANCE CURRENTLY SET TO 0.100E-02
IF TOLERANCE SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0
TOLERANCE FOR STURM SEQUENCE CHECK FOR MISSING EIGENVALUES
SET AT 0.01000 IF TOLERANCE SATISFACTORY ENTER 0
ENTER NEW VALUE IF FINER TOLERANCE REQUIRED
0

TO PLOT ADDED MASS MODEL
ENTER 1 TO PLOT
0 TO CONTINUE
1
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1
PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING

```
DO YOU WISH TO USE DEFAULT PLOTTING  SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES )
1
DEFAULT VALUES NOW BEING SET ......

ENTER COMMAND STRING

PLOT

AFTER PLOTTING USE :
  C - TO DISPLAY COORDINATES OF SELECTED NODES
  L - TO LABEL NODES WITH CURSOR
  W - TO WINDOW
  R - TO RECOVER ORGINAL
PRESS "RETURN" TO PLOT
```

The resulting plot is shown in Figure 8.11.

```
ENTER COMMAND STRING

STOP
```

8.4 Half Model

```
RUN SUBHUL
INPUT A 5 CHARACTER DATA FILE NAME
HALFM
NEW FILE NAME
TO CONTINUE = 0
TO CHANGE NAME = 1
0
SAIL TO BE INCLUDED
YES = 0
NO = 1
1
SAIL IS NOT INCLUDED WITH PRESSURE HULL
ENTER 0 TO CONTINUE
    1 TO CHANGE
0
ENTER UP TO 90 CHARACTER TITLE
TEST OF SUBHUL HALF MODEL

TITLE: TEST OF SUBHUL HALF MODEL
ENTER 0 TO CONTINUE
    1 TO CHANGE
0
ENTER UNITS FOR DIMENSIONS
0 = NIL
1 = IN.
2 = FT.
```

```
3 = MM.
4 = M.
1
ENTER UNITS OF FORCE
0 = NIL
1 = LB.
2 = KIPS.
3 = N.
4 = KN.
5 = MN.
1
UNITS CHOSEN FOR DIMENSION AND FORCE = IN.  AND LBS
CORRECT  YES=0  NO=1
0

CHOOSE PRESSURE HULL FORM
CONVENTIONAL FLAT DECK FORM ENTER 0
AXISYMMETRIC HULL FORM ENTER 1
STEPPED AXISYMMETRIC HULL FORM ENTER 2
1
ENTER THE NO OF DIA REQUIRED TO DESCRIBE THE PRESS HULL
3
ENTER THE DIAMETERS STARTING AT BOW
DIAMETER  1
240
DIAMETER  2
250
LAST DIAMETER  3
200
ENTER DIAMETER LOCATIONS AS DIST FROM FWD PERP
DIST  1
0
DIST  2
1000
LAST DIST  3
2000

DIAMETERS AND DISTANCES CHOSEN
  1    240.00       0.00
  2    250.00    1000.00
  3    200.00    2000.00
IS THERE AN ERROR IN THE DATA
 IF YES ENTER THE LINE NUMBER
  IF NO ENTER 0
0
ENTER  2 PLATE THICKNESSES ONE FOR EACH TWO DIA
BETWEEN DIAMETERS      240.00      250.00
1
BETWEEN DIAMETERS      250.00      200.00
1
 THICKNESS   BETWEEN DIAMETERS
    1.00        240.00  250.00
    1.00        250.00  200.00
IS THERE AN ERROR IN THE DATA
```

IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
ENTER SPHERICAL RADII OF BOW AND STERN DOMED ENDCAPS
150
100
1 SPHERICAL RADIUS OF BOW DOMED ENDCAP 150.000
2 SPHERICAL RADIUS OF STERN DOMED ENDCAP 100.000
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
ENTER BOW ENDCAP THICKNESS
1
ENTER STERN ENDCAP THICKNESS
1
1.00 1.00 BOW ENDCAP AND STERN ENDCAP THICKNESS
IS THERE AN ERROR IN THE DATA
IF YES ENTER THE LINE NUMBER
IF NO ENTER 0
0
IS A PATRAN SESSION FILE TO BE CREATED
YES = 0
NO = 1
1
ENTER NO OF BULKHEADS
1
ENTER THE BULKHEAD LOCATIONS AS DISTANCE FROM BOW
ENTER BULKHD 1 DIST
1250
NO DISTANCE
1 1250.000
IS BULKHEAD DATA CORRECT YES = 0 NO = 1
0
ENTER 1 BULKHEAD PLATE THICKNESSES
BULKHD 1 THICKNESS
1
NO. BULKHD THICKNESS
1 1.000
IS BULKHEAD DATA CORRECT YES = 0 NO = 1
0
ENTER NUMBER OF CIRCUMFERENTIAL ELEMENTS (MAX. 16)
6
FOR HALF CYLINDER MODEL ENTER 1
FULL CYLINDER MODEL ENTER 2
1

ARE SHELL RING STIFFENERS REQUIRED
YES=0
NO=1
0
CHOOSE METHOD FOR DEFINING RING STIFFENER SIZE
1 = CROSSECTION PROPERTIES
2 = T SECTION DIMENSIONS

2
FOR EACH DIAMETER AND DISTANCE ENTER THE FLANGE WIDTH AND THICKNESS AND WEB DEPTH AND THICKNESS

NO.	DIAMETER	DISTANCE
1	240.000	0.000

8 .5 12 .375

NO.	DIAMETER	DISTANCE
2	250.000	1000.000

8 .5 15 .375

NO.	DIAMETER	DISTANCE
3	200.000	2000.000

8 .5 12 .375

NO.	FLANGE	THICK	WEB	THICK	WIDTH	DEPTH	NEUT AXIS
1	8.00	0.50	12.00	0.38	0.61	13.90	8.94
2	8.00	0.50	15.00	0.38	0.55	17.51	10.72
3	8.00	0.50	12.00	0.38	0.61	13.90	8.94

ARE THE VALUES CORRECT
YES=0
NO=1
0
CONVERT NEUTRAL AXIS DIMENSIONS TO ECCENTRICITY BY ENTERING SHELL THICKNESS
AT FOLLOWING DIAMETERS AND DISTANCES (NEGATIVE VALUES PLACE STIFFENER ON INSIDE

NO	DIAMETER	DISTANCE
1	240.000	0.000
2	250.000	1000.000
3	200.000	2000.000

-1 -1 -1
ARE THE VALUES CORRECT
YES=0
NO=1
0

FOR EACH SPACE AND DIST LISTED BELOW
ENTER THE NUMBER OF RING STIFFENERS BETWEEN

NO.	SPACING	DISTANCE
1	1000.000	1000.000
2	500.000	1500.000
3	500.000	2000.000

12 6 6
ARE THE VALUES CORRECT
YES=0
NO=1
0
ARE ALL RING STIFFENERS BETWEEN THE SAME SIZE
YES = 0
NO = 1
0
ENTER STIFFENER FLANGE WIDTH AND THICKNESS AND WEB DEPTH AND THICKNESS
7 .5 10 .375

```
ARE THE VALUES CORRECT
YES=0
NO=1
0
ENTER THE PLATE THICKNESS FOR THE FOLLOWING SPACES
(NEGATIVE VALUES PLACES STIFFENERS ON THE INSIDE OF HULL)
NO.   SPACING   DISTANCE
 1    1000.000     0.000
 2     500.000  1000.000
 3     500.000  1500.000
-1 -1 -1
 SPACE   THICKNESS
  1000.00   -1.000
   500.00   -1.000
   500.00   -1.000
ARE THE VALUES CORRECT
YES=0
NO=1
0
EQUIVALENT CURVED BEAM CROSSECTION
SPACE    BEAM WIDTH    BEAM DEPTH  ECCENTRICITY
  1000.00     0.63     11.59    -8.03
   500.00     0.63     11.59    -8.03
   500.00     0.63     11.59    -8.03
ARE THE VALUES CORRECT
YES=0
NO=1
0
ENTER THE NUMBER OF SHELL ELEMENTS BETWEEN RING BEAMS
1
ARE THE ELEMENTS BETWEEN BEAMS= 2 CORRECT
YES=0
NO=1
0
ENTER THE NUMBER OF AXIAL ELEMENTS IN DOMED END CAPS
3
NUMBER OF SHELL NODES= 693
NUMBER OF SHELL DEGREES OF FREEDOM=3465
IF NUMBER DEGREES OF FREEDOM TOO HIGH ENTER 1 TO RESTART
ENTER 0 TO CONTINUE
0
MATERIAL PROPERTIES ARE SAME THROUGHOUT STRUCTURE
YES = 0
 NO = 1
0
ENTER YOUNGS MODULUS-POISSONS RATIO-DENSITY FOR STRUCTURE
30000000 .3 .000733
GEOMETRY AND ELEMENT GENERATION COMPLETE

TO END AND PRINT GEOMETRY AND ELEMENT DATA ENTER 1
 TO EXAMINE RING STIFFENER ARRANGEMENT ENTER 2
 TO PROCEED AND GENERATE A VAST ANALYSIS FILE ENTER 3
2
DO YOU WISH TO EXAMINE RING STIFFENER SIZE AND LOCATION
```

```
YES = 0   NO = 1
0
TO LIST STIFFENERS = 1
TO PLOT STIFFENERS = 2
TO STOP = 3
TO CONTINUE =0
2

WHAT IS THE LINE SPEED?
9600

IDENTIFY TERMINAL TYPE ACCORDING TO RESOLUTION,
CURSOR AND COLOUR CAPABILITY:
ENTER 0 FOR TEKTRONIX 4006 OR EQUAL (LOW RES/NO CURS/NO COL)
    1 FOR TEKTRONIX 401* OR EQUAL (LOW RES/CURSORS/NO COL)
    2 FOR TEKTRONIX 4014/15 (HI RES/CURSORS/NO COL)
    3 FOR TEKTRONIX 4113 (COLOUR):
2

IDENTIFY TERMINAL TYPE ACCORDING TO DIALOG CAPABILITY:
ENTER 0 NO DIALOG AREA
    1 DIALOG AREA

0
```

The resulting plot is shown in Figure 8.12.

```
TO LIST STIFFENERS = 1
TO PLOT STIFFENERS = 2
TO STOP = 3
TO CONTINUE =0
0

IS FLUID INTERACTION TO BE CONSIDERED
YES ENTER 0
NO  ENTER 1
1
ENTER TYPE OF ANALYSIS

1 = STATIC
2 = BUCKLING RUN #1 (TO GET INITIAL STRESSES)
3 = NATURAL FREQUENCY
5 = BUCKLING RUN #2(CRITICAL LOAD)
6 = NATURAL FREQUENCY RUN #1(HULL UNDER PRESS)
7 = NATURAL FREQUENCY RUN #2(HULL UNDER PRESS)
1
IS BANDWIDTH REDUCTION REQUIRED

YES=0
NO=1
0
ARE ELEMENTS STRESSES REQUIRED

YES=1
```

NO=0
1
GEOMETRY DATA CHECK
NO ENTER 0
YES ENTER 3
0
ARE RESIDUAL STRESSES TO BE ACCOUNTED FOR   YES=2 NO=0
0
TO PLOT STRUCTURAL MODEL ENTER 1
TO CONTINUE ENTER 0
1
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1
PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING
        FINITE ELEMENT MODELS

SPECIFY LENGTH UNITS USED IN THIS ANALYSIS;
(FOR UNITS: NIL IN. FT. MM. M.
   ENTER: 0 1 2 3 4):
1
SPECIFY FORCE UNITS USED IN THIS ANALYSIS;
(FOR UNITS: NIL LBS. KIPS.   N.   KN.   MN.
   ENTER: 0   1   2   3   4   5):
1
ENTER 0 FOR VIEWING VECTOR APPROACH
  OR 1 FOR FINITE ANGULAR ROTATIONS:
1
DO YOU WISH TO USE DEFAULT PLOTTING SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1
DEFAULT VALUES NOW BEING SET ......

ENTER COMMAND STRING

VIEW
* VIEW / ELEMENT / B.C. SPECIFICATIONS *

ENTER ROTATIONS ABOUT BODY-FIXED AXES Z, Y & X
AND PLOT REDUCING FACTOR (PERCENT):
10 45 10 10
ENTER COMMAND STRING

PLOT

AFTER PLOTTING USE :
        C - TO DISPLAY COORDINATES OF SELECTED NODES
        L - TO LABEL NODES WITH CURSOR
        W - TO WINDOW
        R - TO RECOVER ORGINAL
        PRESS "RETURN" TO PLOT

The resulting plot of the structural is shown in figure 8.13.

ENTER COMMAND STRING

STOP

DEFINE BOUNDARY CONSTRAINTS
HALF CYLINDER POSITIVE DEFINITE SYSTEM MODEL = 1
HALF CYLINDER PARTIALLY CONSTRAINED MODEL = 2
1

TO PLOT BOUNDARY CONDITIONS ENTER 2
TO CONTINUE ENTER 0
2
DO YOU WISH PROGRAM OPERATION TO BE VIA COMMAND STRINGS?
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1
PROGRAM PLOTV1: VAST05 GRAPHICS PROGRAM FOR PLOTTING
FINITE ELEMENT MODELS

DO YOU WISH TO USE DEFAULT PLOTTING SPECIFICATIONS ?
(ENTER -1=MORE INFORMATION 0=NO 1=YES)
1

ENTER COMMAND STRING

VIEW
* VIEW / ELEMENT / B.C. SPECIFICATIONS *

ENTER ROTATIONS ABOUT BODY-FIXED AXES Z, Y & X
AND PLOT REDUCING FACTOR (PERCENT):
10 45 10 10
ENTER COMMAND STRING
BCON

DO YOU WANT THE BOUNDARY CONDITIONS INDICATED? (0=NO):
1
DO YOU WANT THE B.C. NODES NUMBERED? (0=NO):
0
ENTER COMMAND STRING

PLOT
AFTER PLOTTING USE :
C - TO DISPLAY COORDINATES OF SELECTED NODES
L - TO LABEL NODES WITH CURSOR
W - TO WINDOW
R - TO RECOVER ORGINAL
PRESS "RETURN" TO PLOT

The resulting boundary condition plot is shown in figure 8.14.

ENTER COMMAND STRING

STOP

LOAD DATA CHECK
NO, ENTER 0
YES, ENTER 3
0
ENTER A TITLE FOR THE LOAD CASE (MAX 72 CHARACTERS)
HULL PRESSURE LOAD

SELECT ELEMENT LOAD OPTIONS:
NO ELEMENT LOADS ARE TO BE COMPUTED, ENTER 0
BODY FORCES, DISTRIBUTED EXTERNAL LOADS, INITIAL STRAIN TO BE COMPUTED, ENTER 1
1
ARE CONCENTRATED LOADS TO BE APPLIED:
YES = 1
NO = 0
0

LOADING OF STRUCTURE UNDER GOING TRANSLATIONAL ACCELERATION AS A RIGID BODY:

FOR SELF WEIGHT DUE TO GRAVITY, ENTER 2
FOR RIGID BODY ACCELERATION, ENTER 1
FOR ZERO ACCELERATION, ENTER 0
0
IS THERE RIGID BODY ROTATIONAL MOTION

IF YES ENTER 1
IF NO ENTER 0
0
ENTER SUBMARINE DEPTH IN FEET
400
ARE PRINTOUTS OF NODAL LOADS,REACTIONS AND DISPLACEMENTS
REQUIRED YES = 1 NO = 0
1
ARE ELEMENT STRESSES TO BE PRINTED BY LINE PRINTER
YES = 1
NO = 0
1
LINE PRINTER OUTPUT IS ON FILE HALFM.LPR
OTHER DATA OUTPUT:
PRESSURE HULL GEOMETRY FILE HALFM.SBH
VAST GEOMETRY FILE HALFM.GOM
VAST BOUNDRY CONDITION FILE HALFM.SMD
VAST LOAD DATA FILE HALFM.LOD

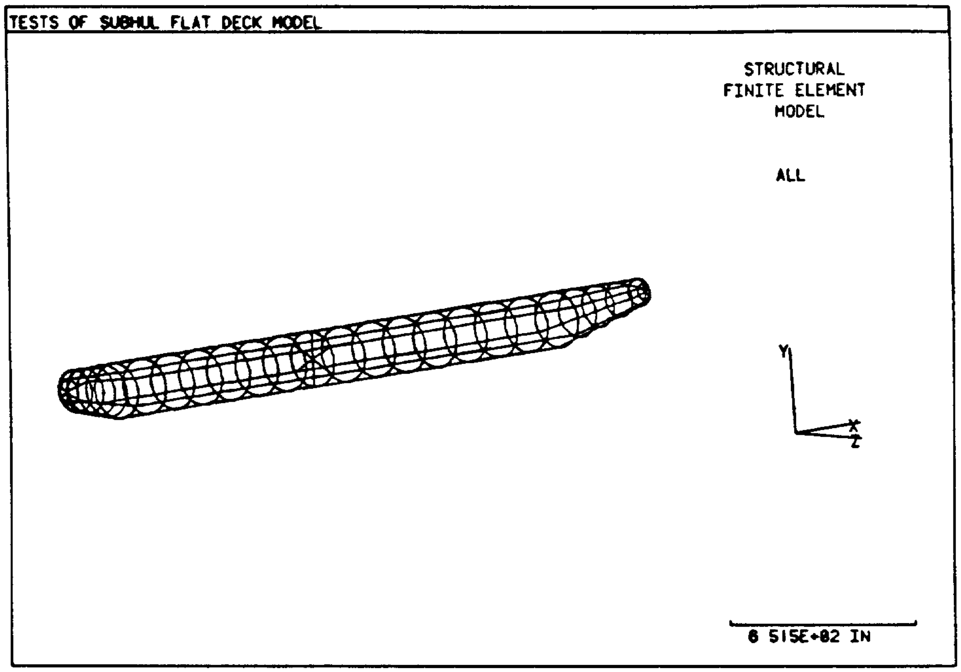


Figure 8.1 Flat Deck Structural Model for Vibration Analysis

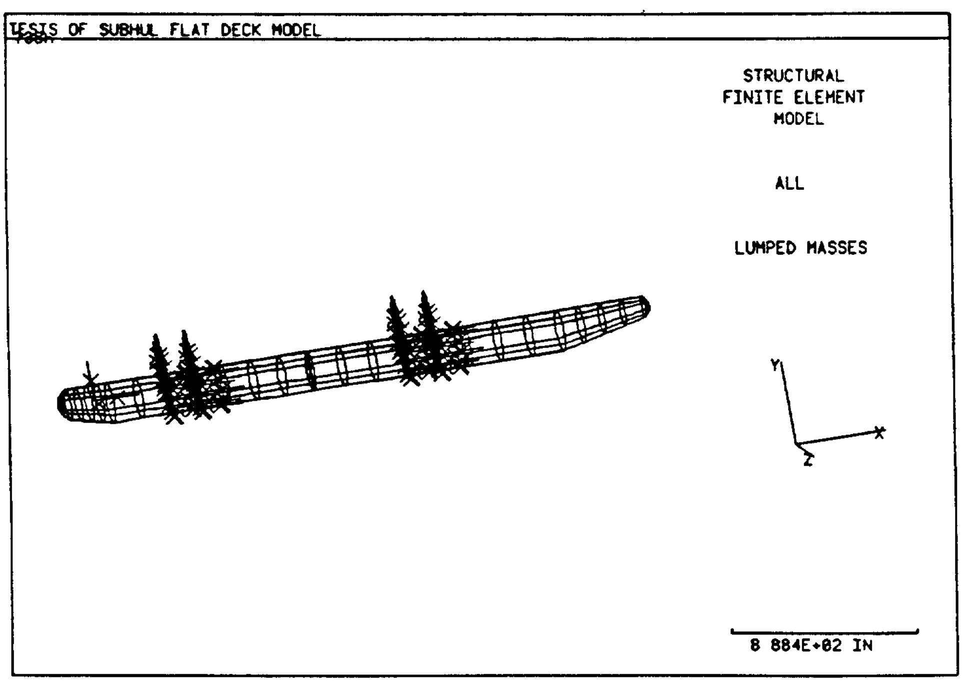


Figure 8.2 Lumped Mass Locations

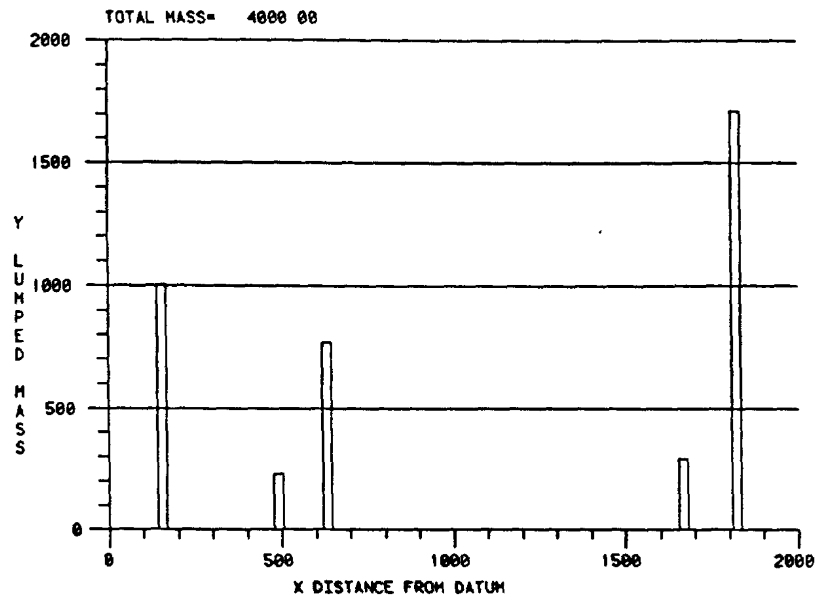


Figure 8.3 Bar Chart of Longitudinal Lumped Mass Locations

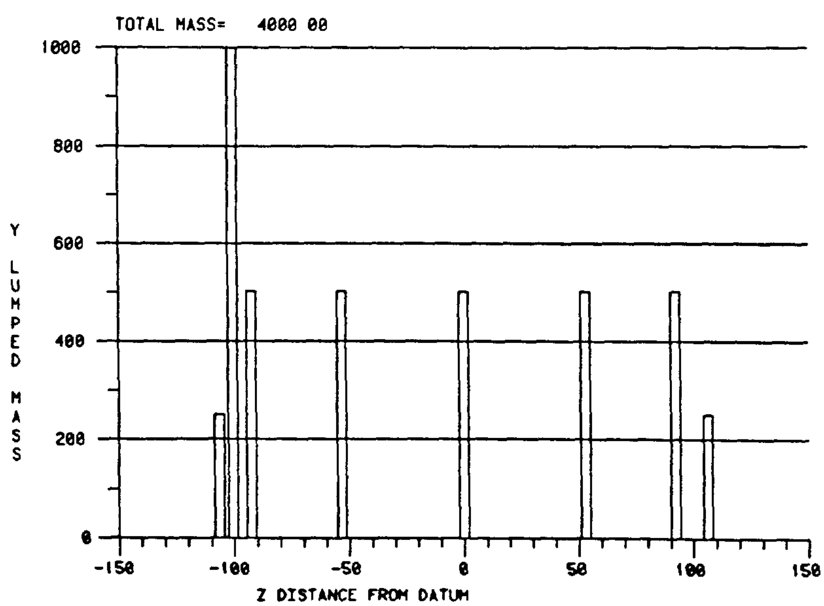


Figure 8.4 Bar Chart of Transverse Lumped Mass Locations

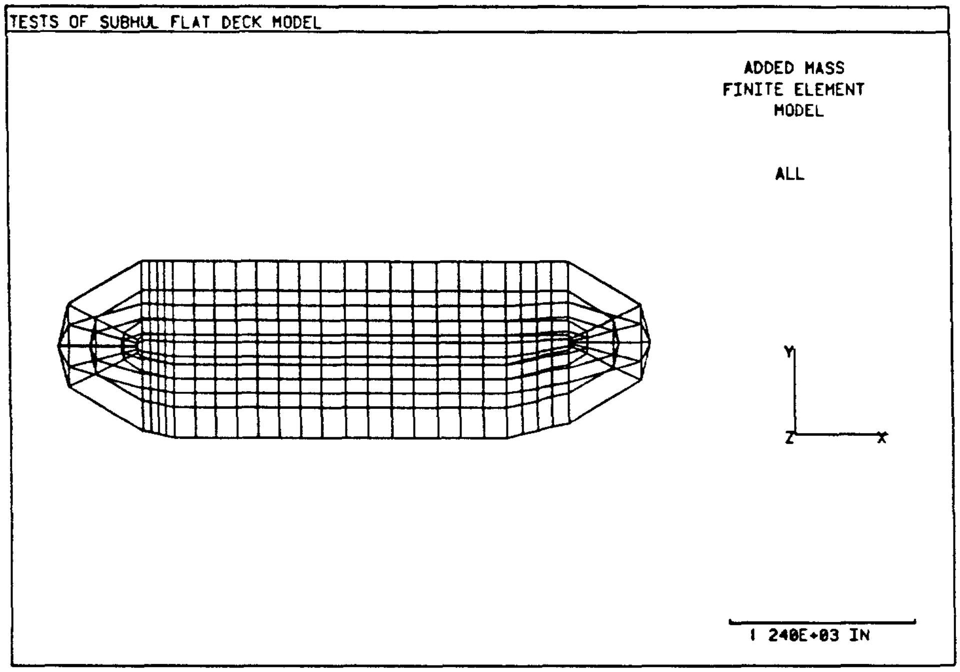


Figure 8.5 Added Mass Fluid Element Model for Flat Deck Model

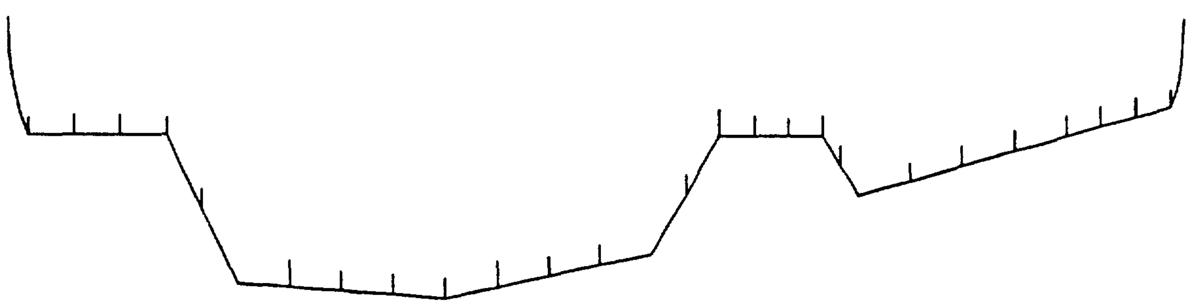


Figure 8.6 Ring Stiffener Location on Stepped Model Half Hull Outline

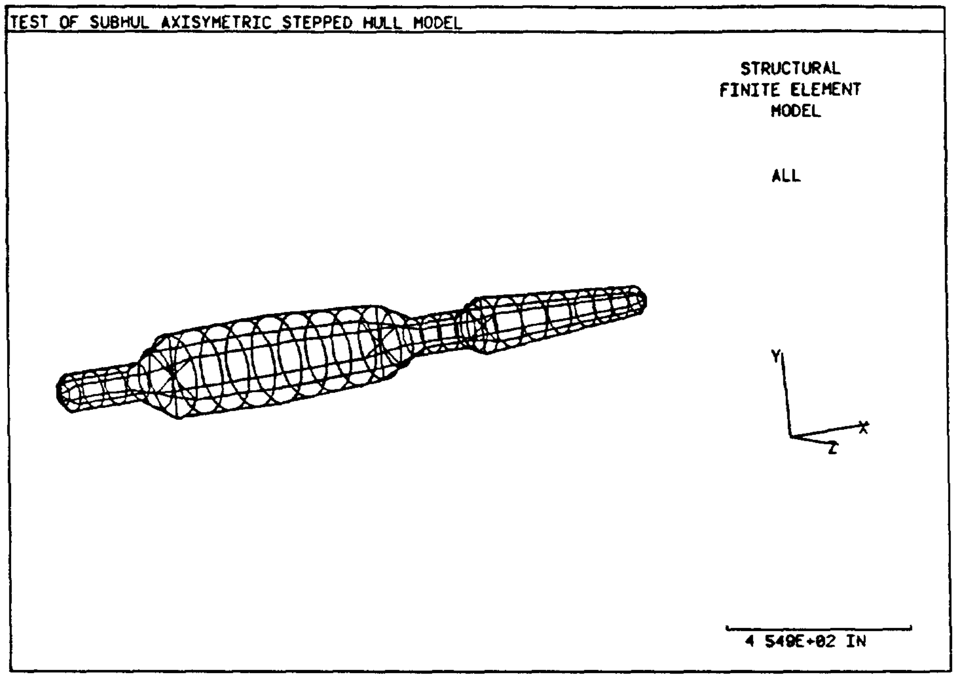


Figure 8.7 Finite Element Model of Stepped Hull

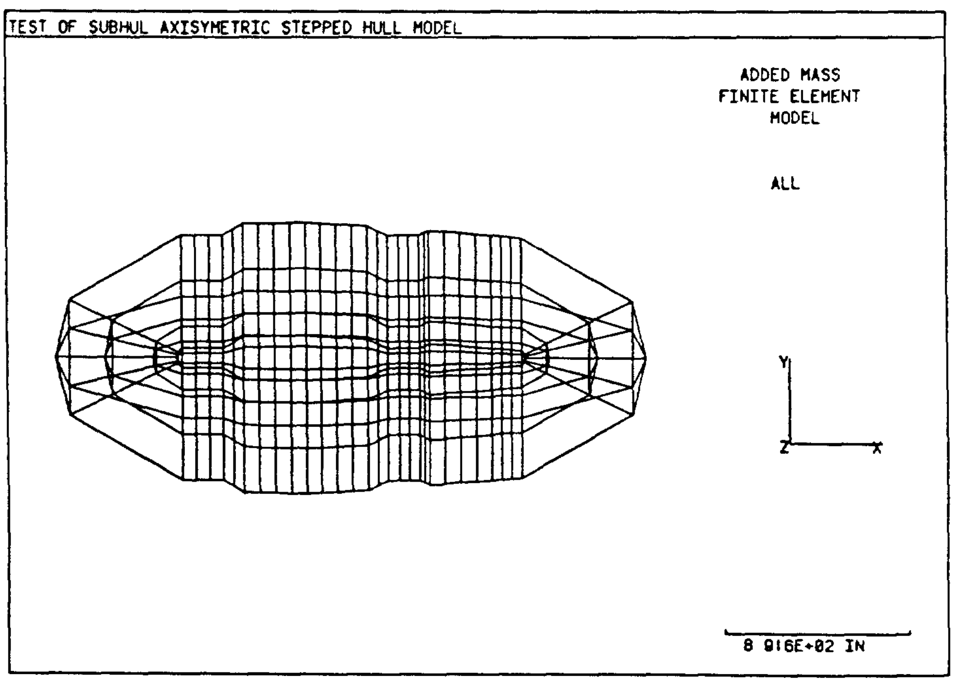


Figure 8.8 Added Mass Fluid Element Model for Stepped Hull

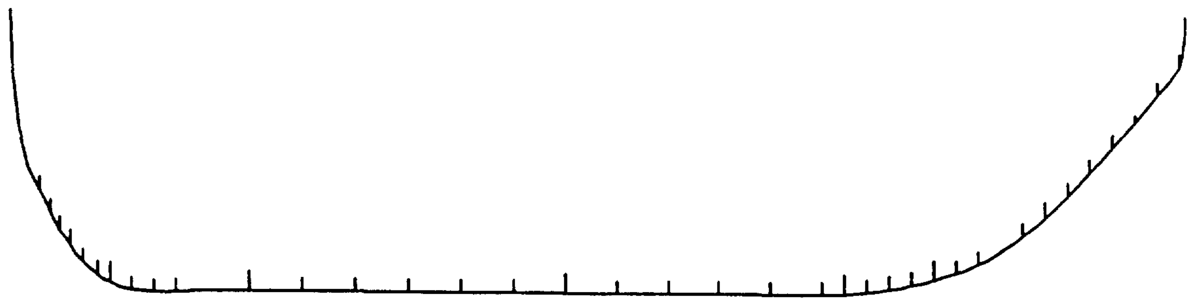


Figure 8.9 Ring Stiffener Location of Smooth Outline Model

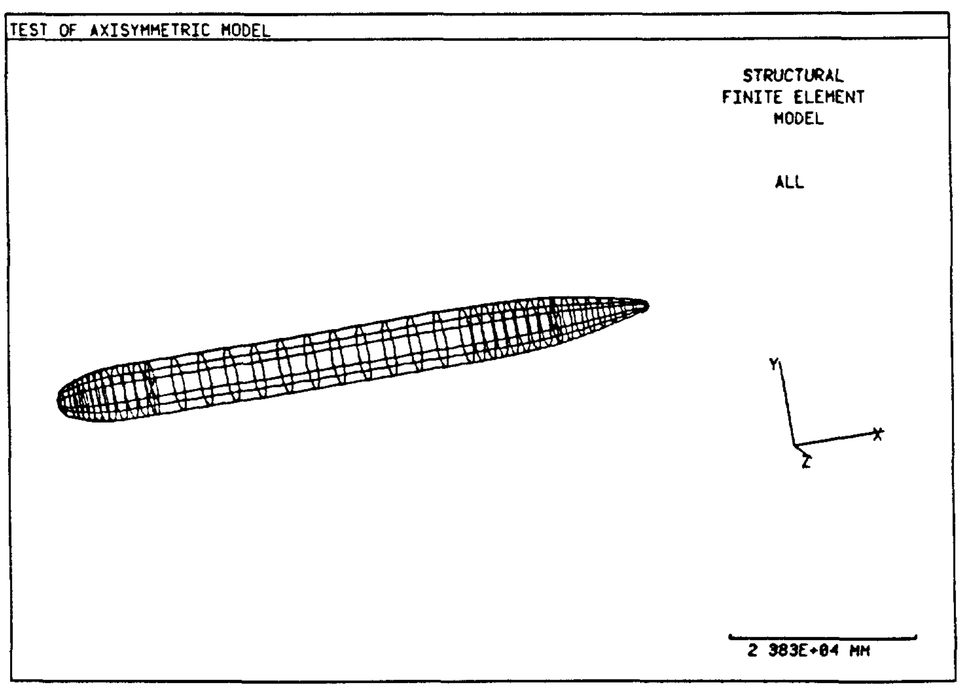


Figure 8.10 Finite Element Model of Smooth Outline Model

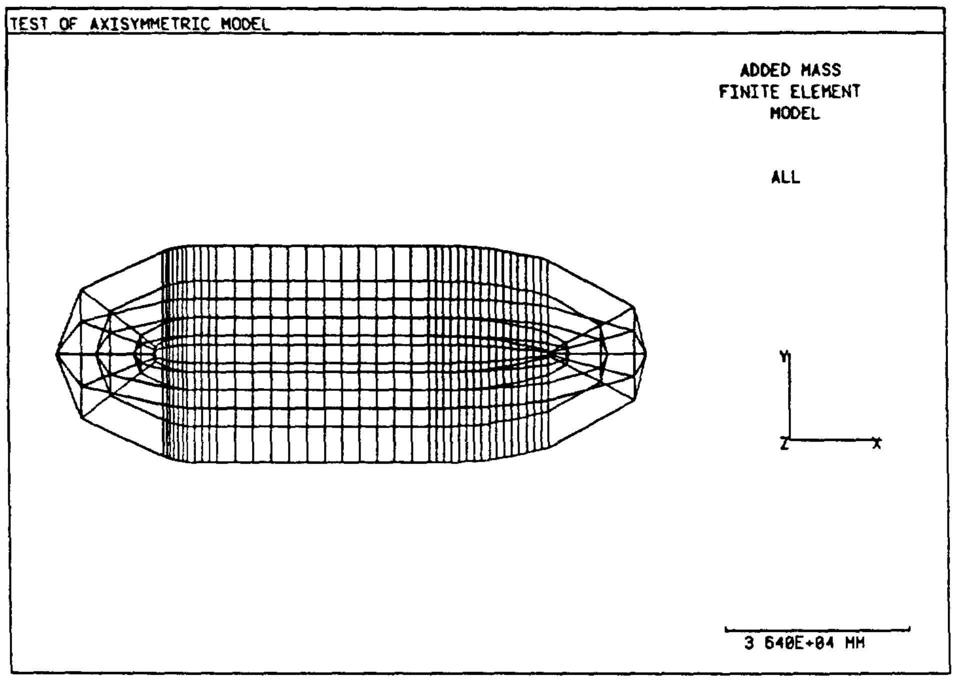


Figure 8.11 Added Mass Fluid Element Model for Smooth Outline Model

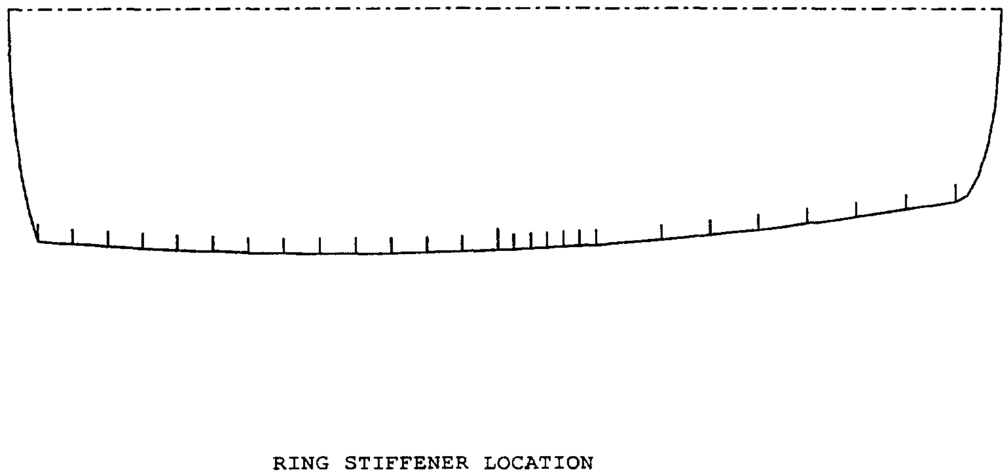


Figure 8.12 Ring Stiffener Location for Half Model

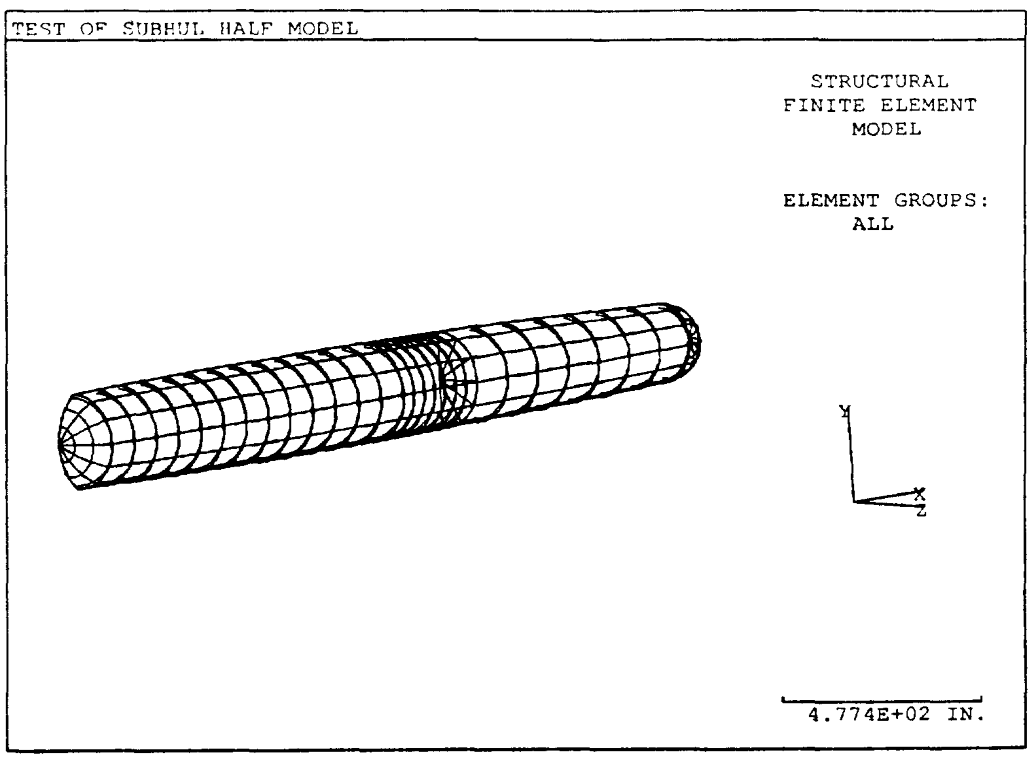


Figure 8.13 Finite Element Model of Half Hull

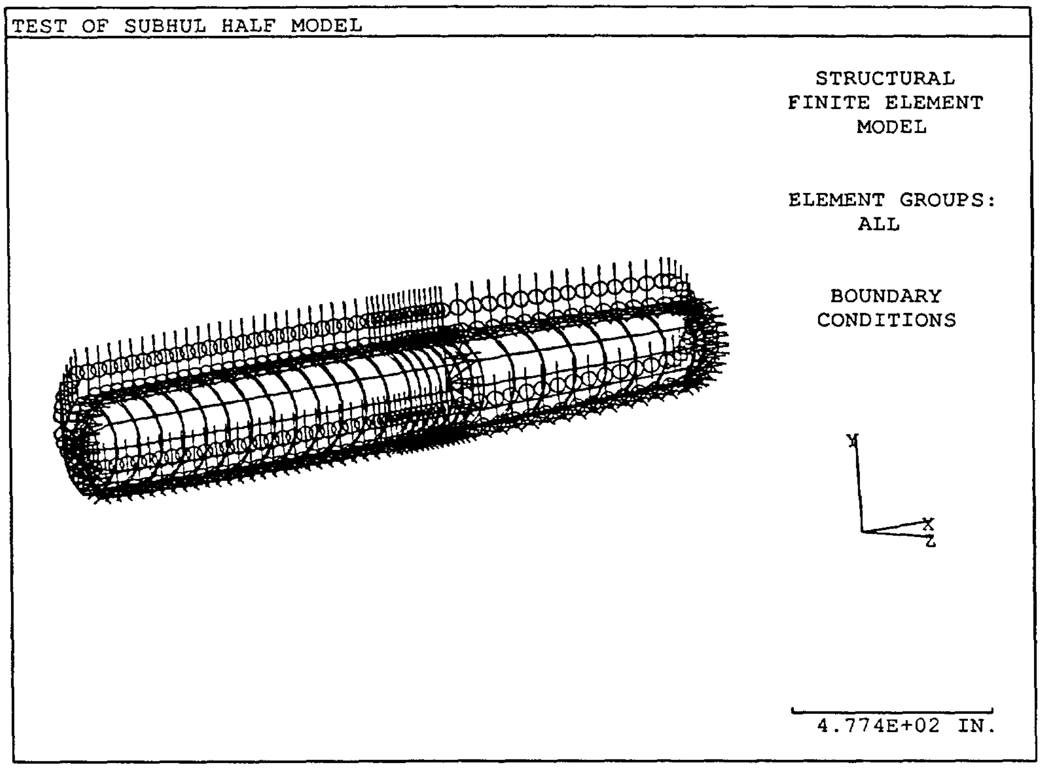


Figure 8.14 Boundary Constraints Applied to Half Hull Model

CHAPTER 9

9. VAST ANALYSIS

Three different examples of VAST analysis for the same pressure hull follow. The model and VAST input files were generated using SUBHUL, and the results presented graphically using VASTG.

9.1 Stress and Displacement Under Hydrostatic Pressure

The basic data file for the model is given in Appendix A and the model description file in Appendix B. The following is the VASTG plotting option list, which can vary depending on the type of analysis.

0 TO RETURN TO MAIN MENU
1 TO PLOT STRUCTURAL FINITE ELEMENT MODEL
3 TO PLOT APPLIED STRUCTURAL LOADS
5 TO PLOT DEFLECTED SHAPES
6 TO PLOT DISPLACEMENT CONTOURS
10 TO PLOT PRINCIPAL STRESS OR STRAIN VECTORS
11 TO PLOT STRESS OR STRAIN CONTOURS
12 TO PLOT STRAIN ENERGY DENSITY CONTOURS

The finite element model is shown in Figure 9.1 and the boundary conditions in Figure 9.2. The pressure load for a depth of 400 feet is shown in Figure 9.3. The hull deflections can be shown by two methods. One method is a plot of the distorted shape in which the distortions have been magnified for ease of interpretation. The distorted shape plot is shown in Figure 9.4. The second method of showing hull deflections under load is by displacement contours, as shown in Figure 9.5. The stresses due to the loading can be plotted as global or local stresses. It is recommended that they be plotted as local stresses as they more closely conform to longitudinal and hoop stresses found in simple pressure vessel analysis. There are eleven stress options available in VASTG, all of which have been plotted for demonstration purposes in Figures 9.6 and 9.7. They cover local stresses in X,Y and Z and their respective shears as well as Von Mises and maximum shear stresses.

9.2 Buckling Under Hydrostatic Pressure

Bifurcation buckling of the hull can be predicted by VAST. The results of a buckling analysis of the sample hull model are shown in Figures 9.8 and 9.9. Six buckling modes are shown with longitudinal and transverse views for each mode. Mode number one can be ignored as it is due to inadequate boundary conditions for torsional constraint applied to a single node at the apex of the bow end cap. The second mode is a better indication of the critical buckling depth, which is obtained by multiplying the factor 6.215 by the input depth of 400 feet for which the stresses were calculated.

CRITICAL DEPTH=6.215*400

=2486 feet

9.3 Natural Frequencies of Vibration

The natural frequencies of vibration of the structure in water were predicted using free free boundary conditions. The water was modelled with fluid elements for one of the two analyses (Figure 9.10). The panel method was used for the second analysis. The results for the fluid element model are shown in Figures 9.11 and 9.12. They are presented as longitudinal and end views of the mode shapes. The first six modes are ignored as they are rigid body modes. The panel method results are shown in Figures 9.13 and 9.14. While the mode shapes obtained from the two methods are identical, the frequencies differ by as much as 16 percent. The differences are due to the over estimation of the fluid mass by the current version of the panel method installed in VAST.

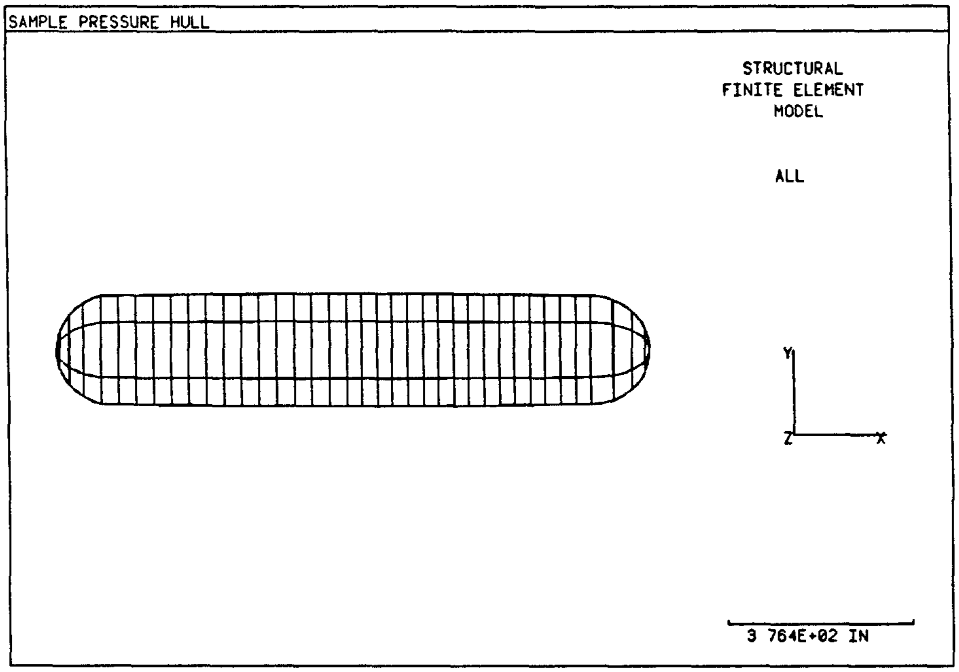


Figure 9.1 Finite Element Model of Pressure Hull for VAST Analysis

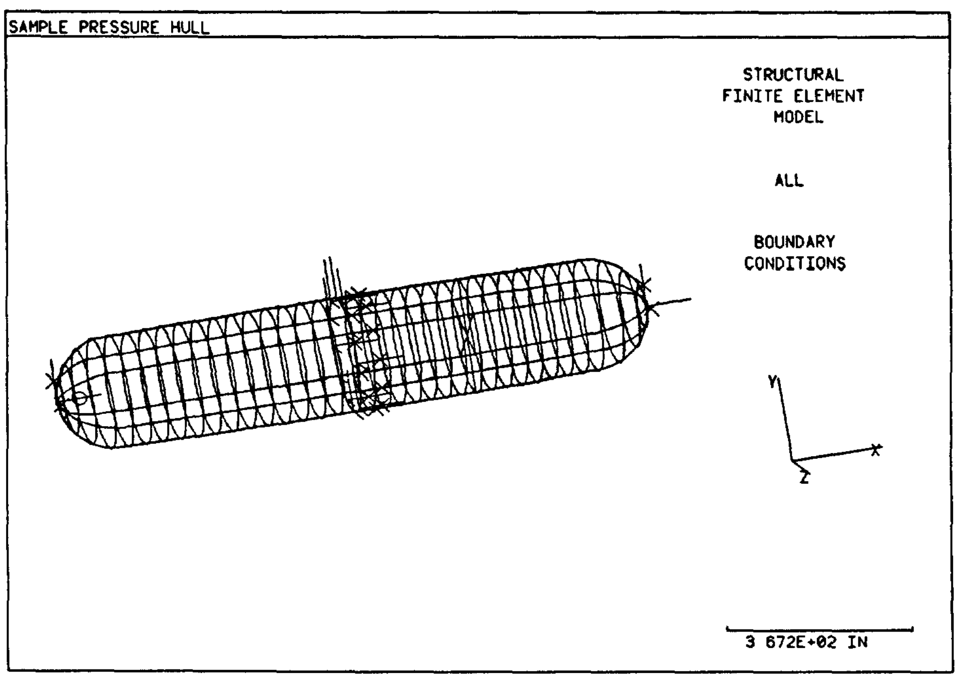


Figure 9.2 Boundary Constraints for Static Stress and Displacement Analysis

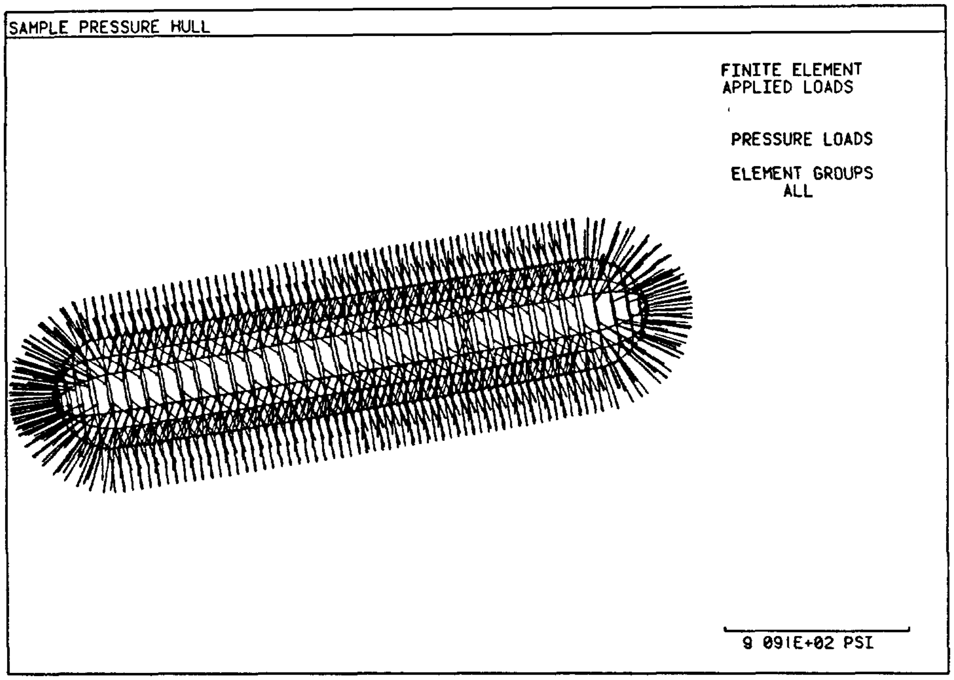


Figure 9.3 Pressure Load Vectors for Static Stress Analysis

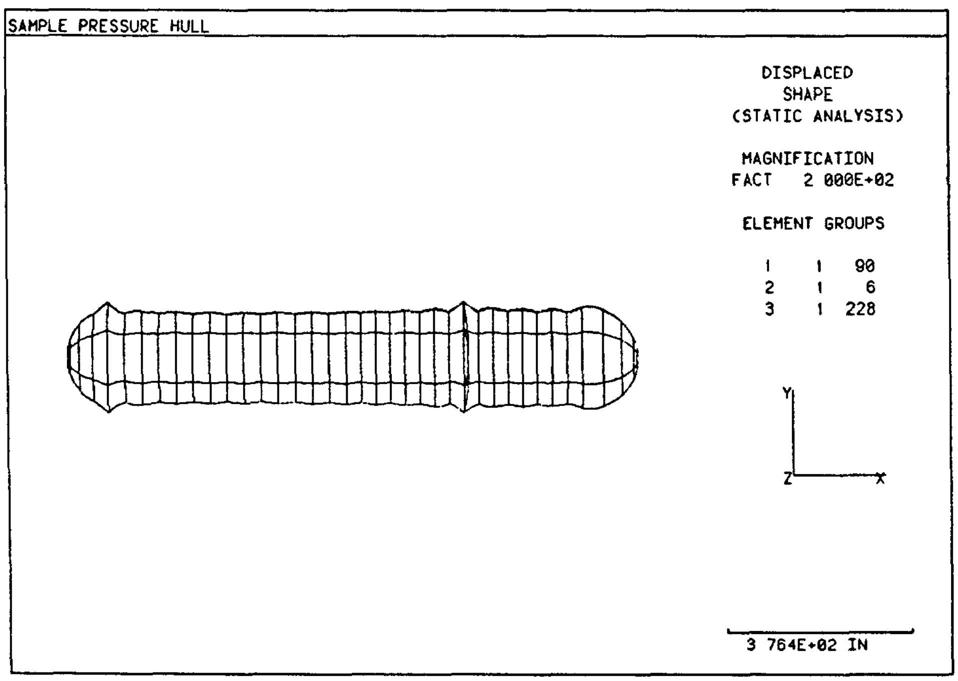


Figure 9.4 Plot of Distorted Shape Due to Pressure Load

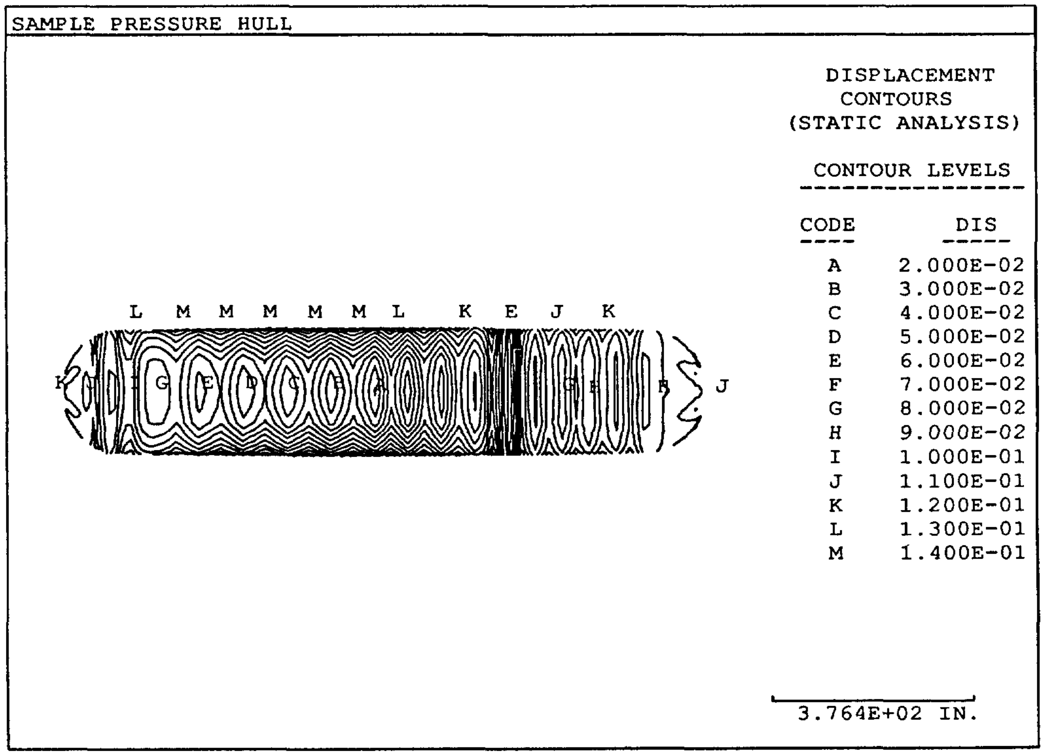


Figure 9.5 Displacement Contours Due to Pressure Load

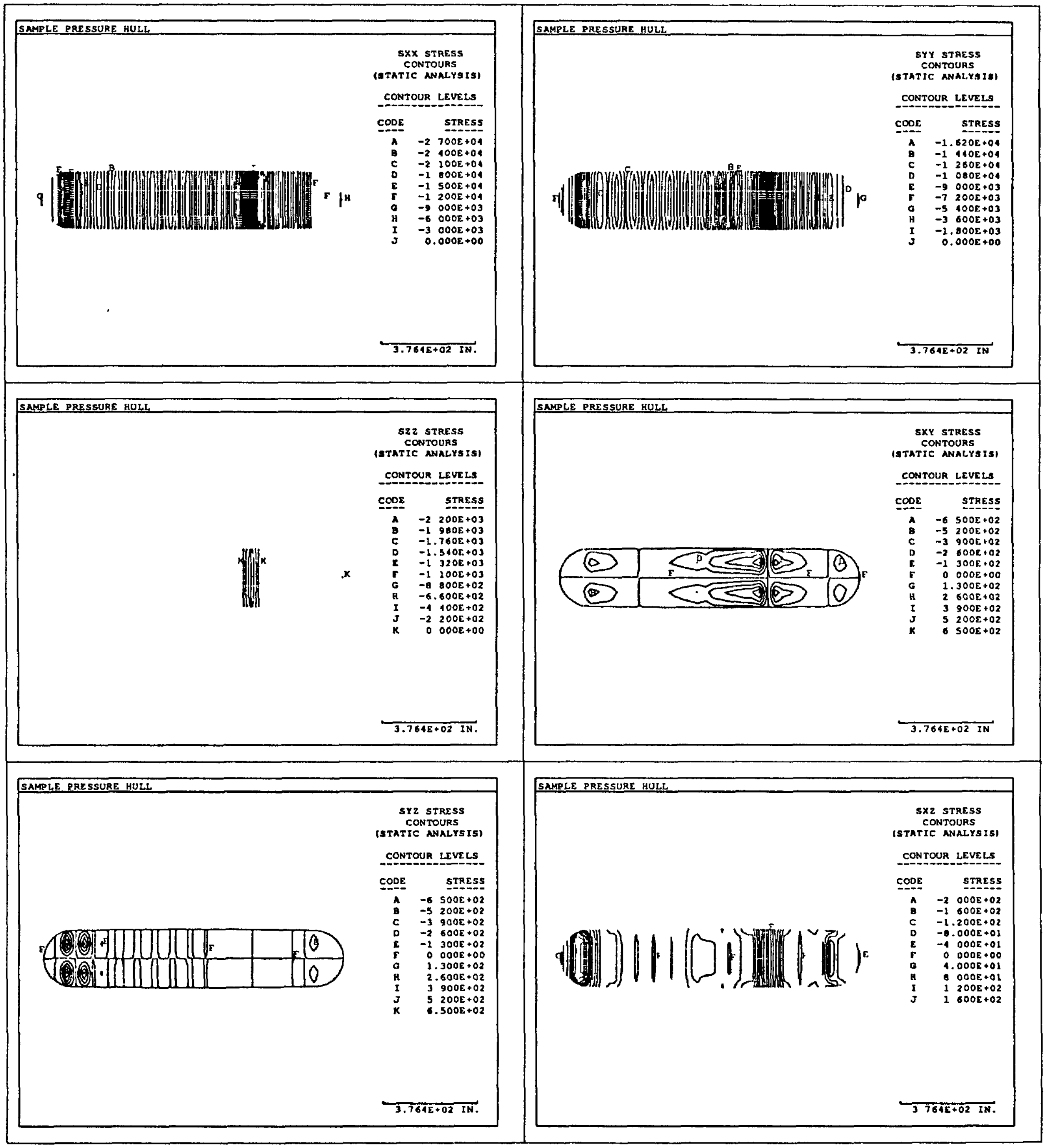


Figure 9.6 Stress Contour Plots of Local Stresses Due to Pressure Load

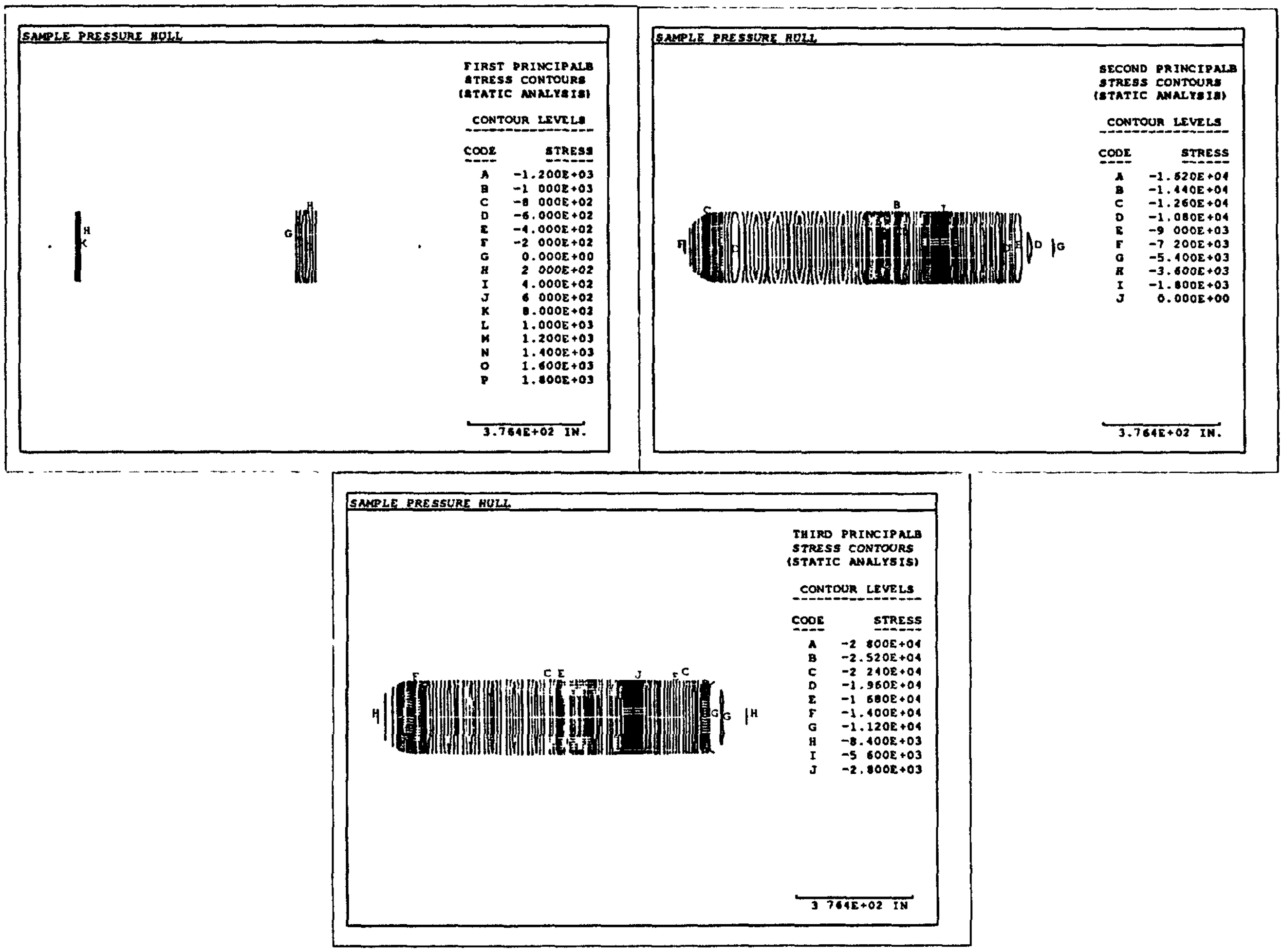


Figure 9.7a Stress Contour Plots of Principal Stresses Due to Pressure Load

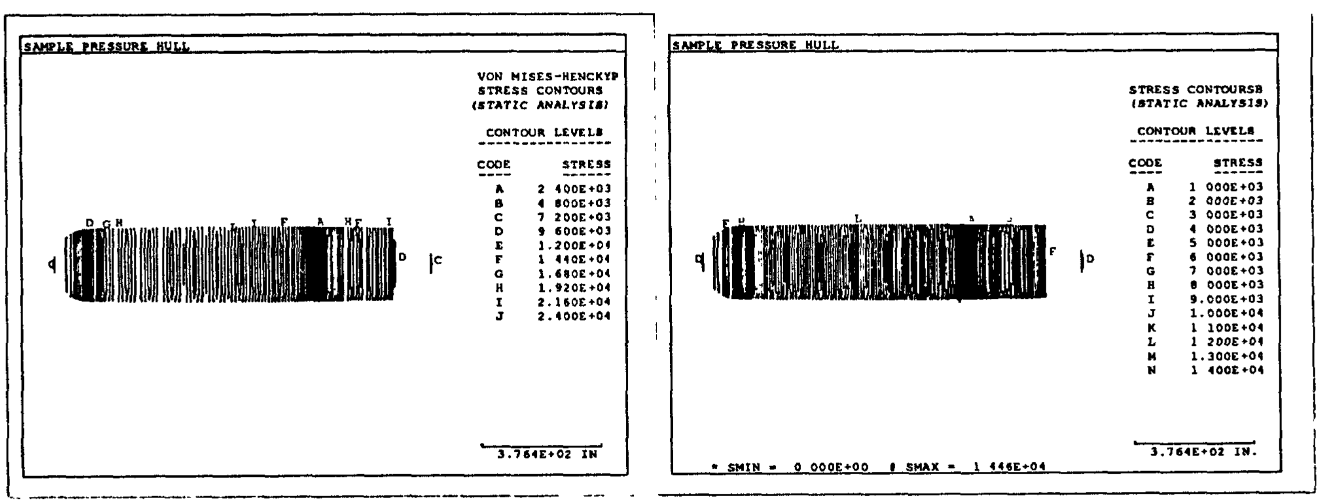


Figure 9.7b Stress Contour Plots of Von Mises and Maximum Shear Stresses

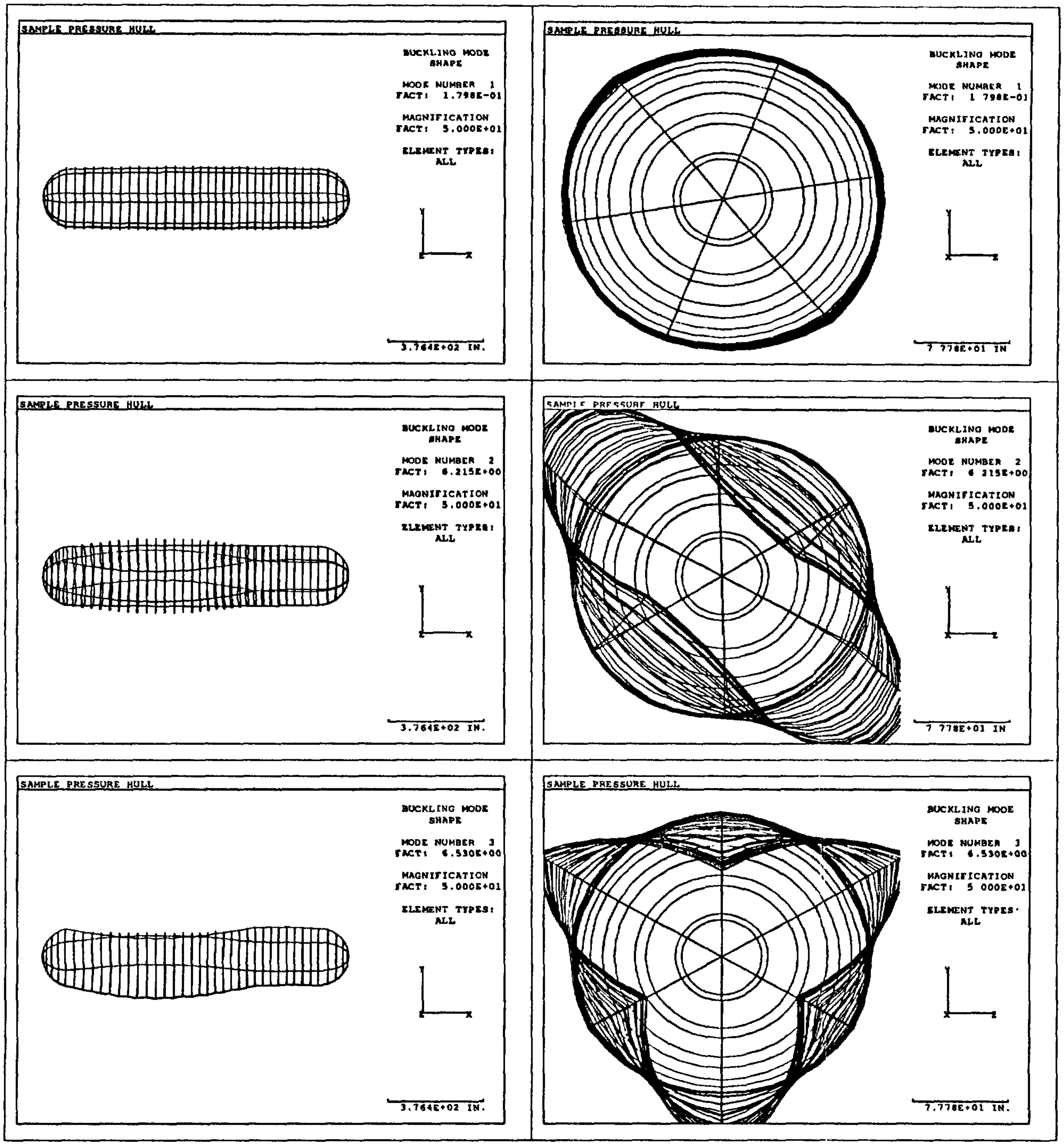


Figure 9.8 Longitudinal and Transverse Bifurcation Buckling for Modes 1 to 3 of Pressure Hull

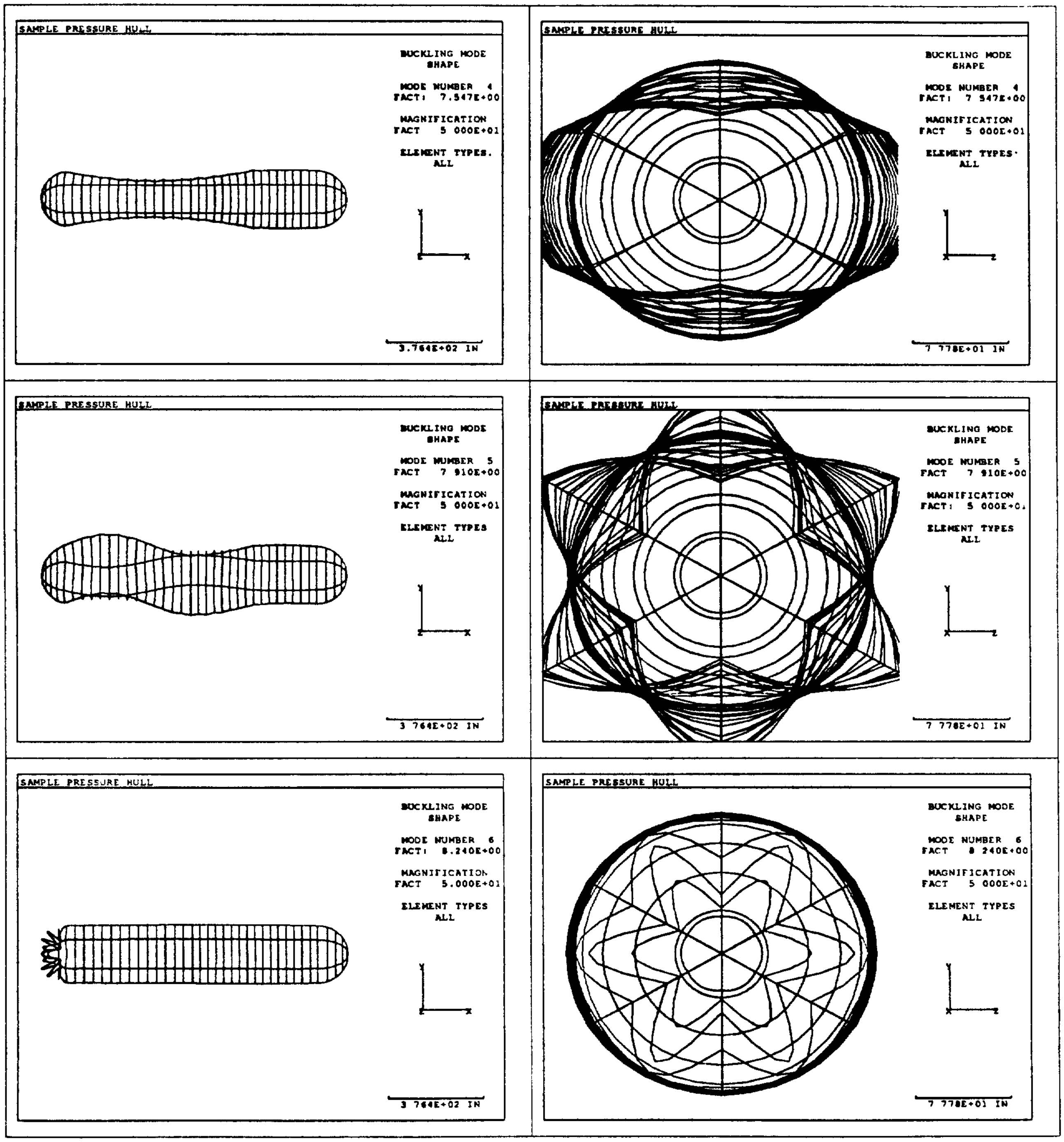


Figure 9.9 Longitudinal and Transverse Bifurcation Buckling for Modes 4 to 6 of Pressure Hull

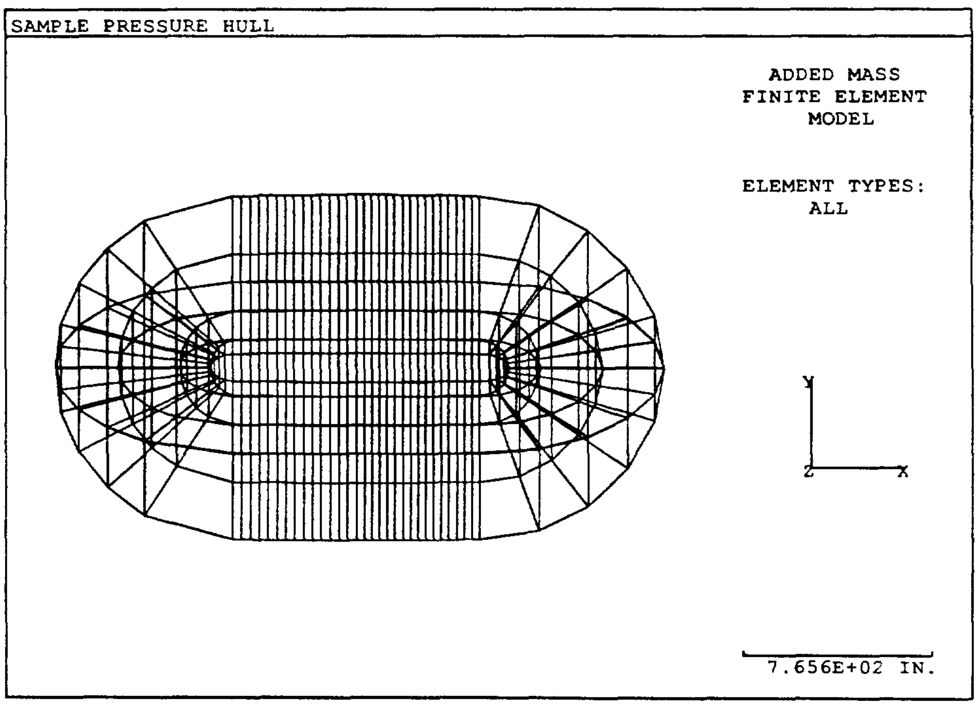


Figure 9.10 Added Mass Fluid Element Model for Pressure Hull

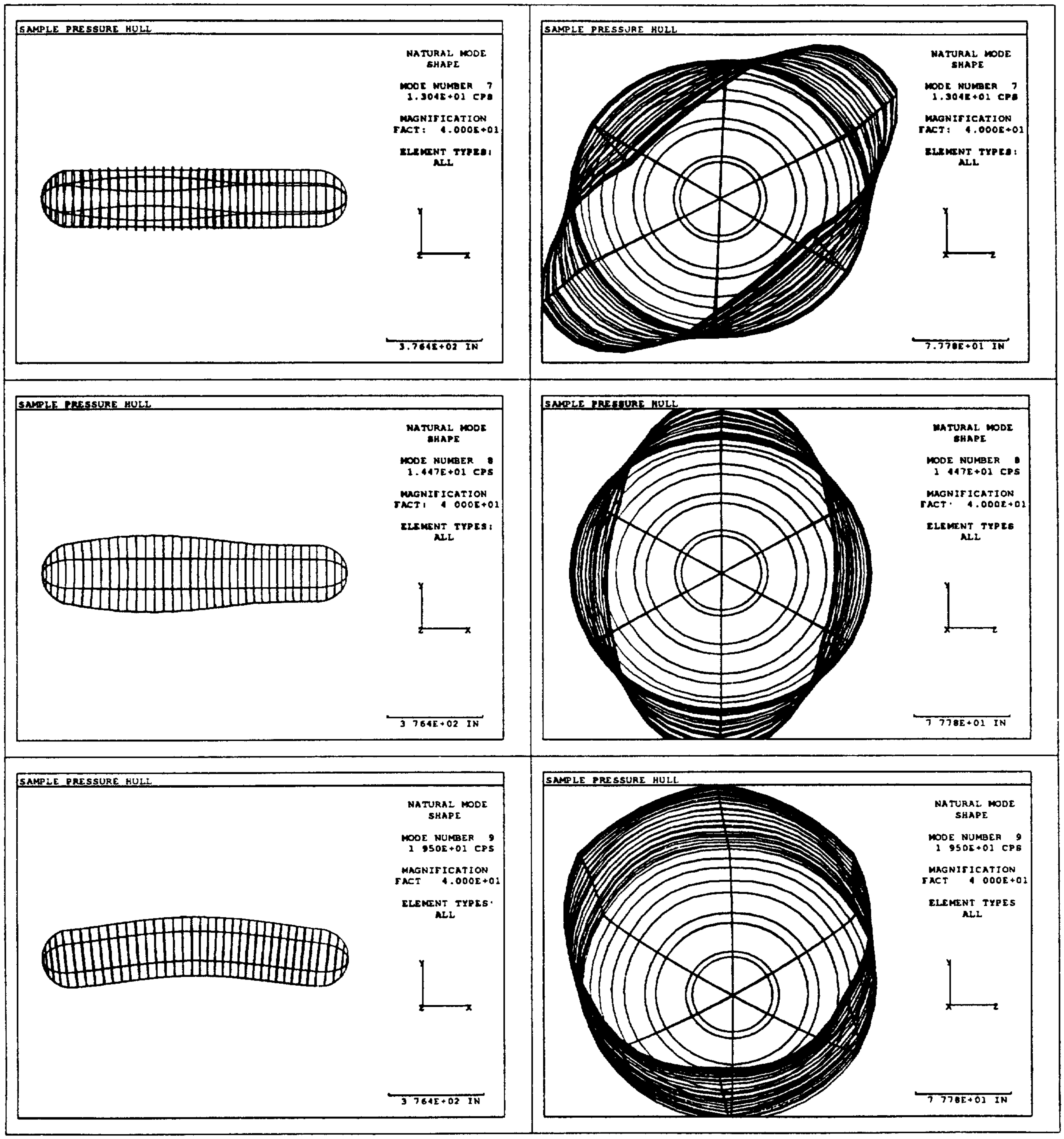


Figure 9.11 In Water Frequencies for Modes 7 to 9 for the Pressure Hull Obtained with the Fluid Element Model

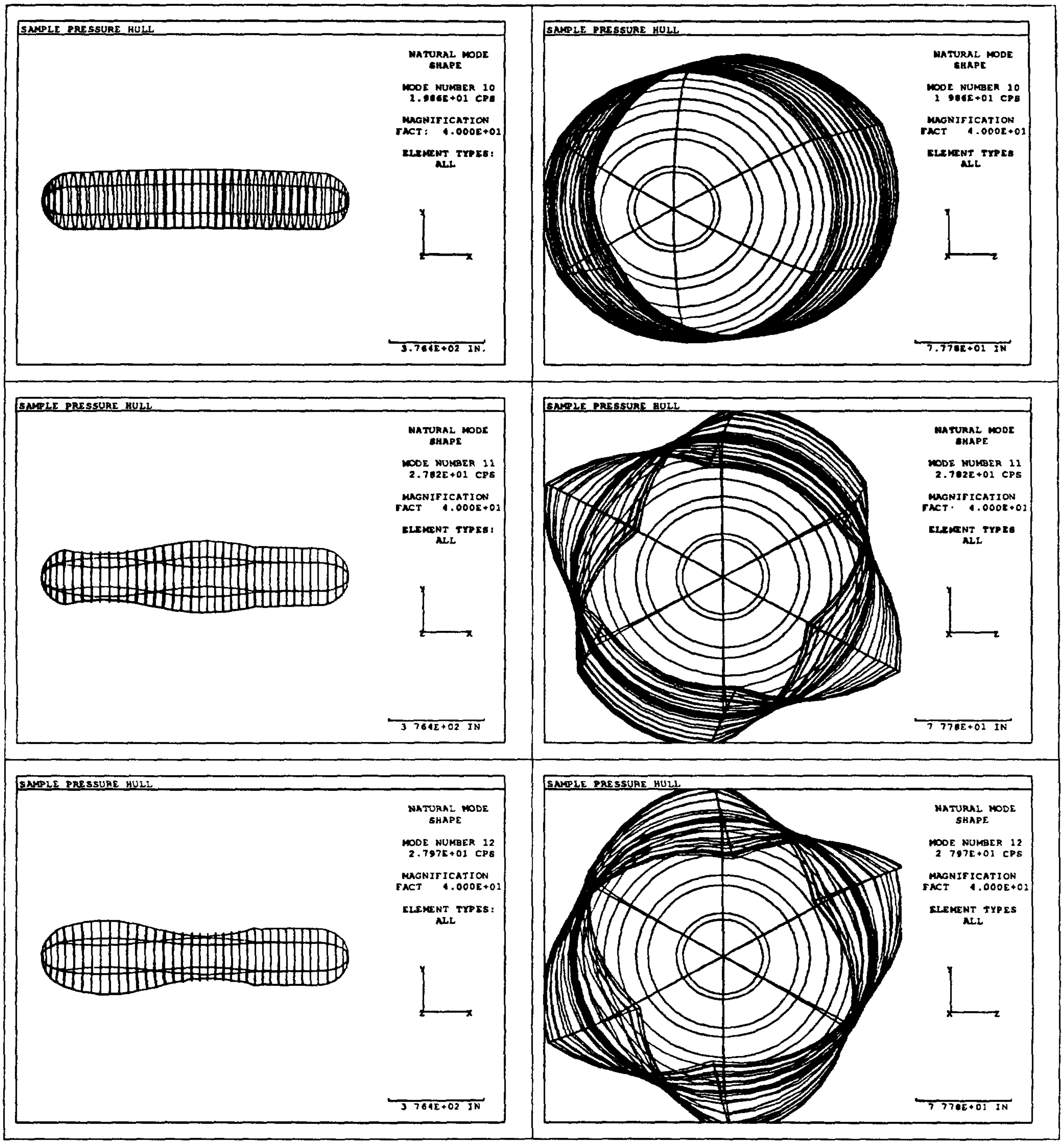


Figure 9.12 In Water Frequencies for Modes 10 to 12 for the Pressure Hull Obtained with the Fluid Element Model

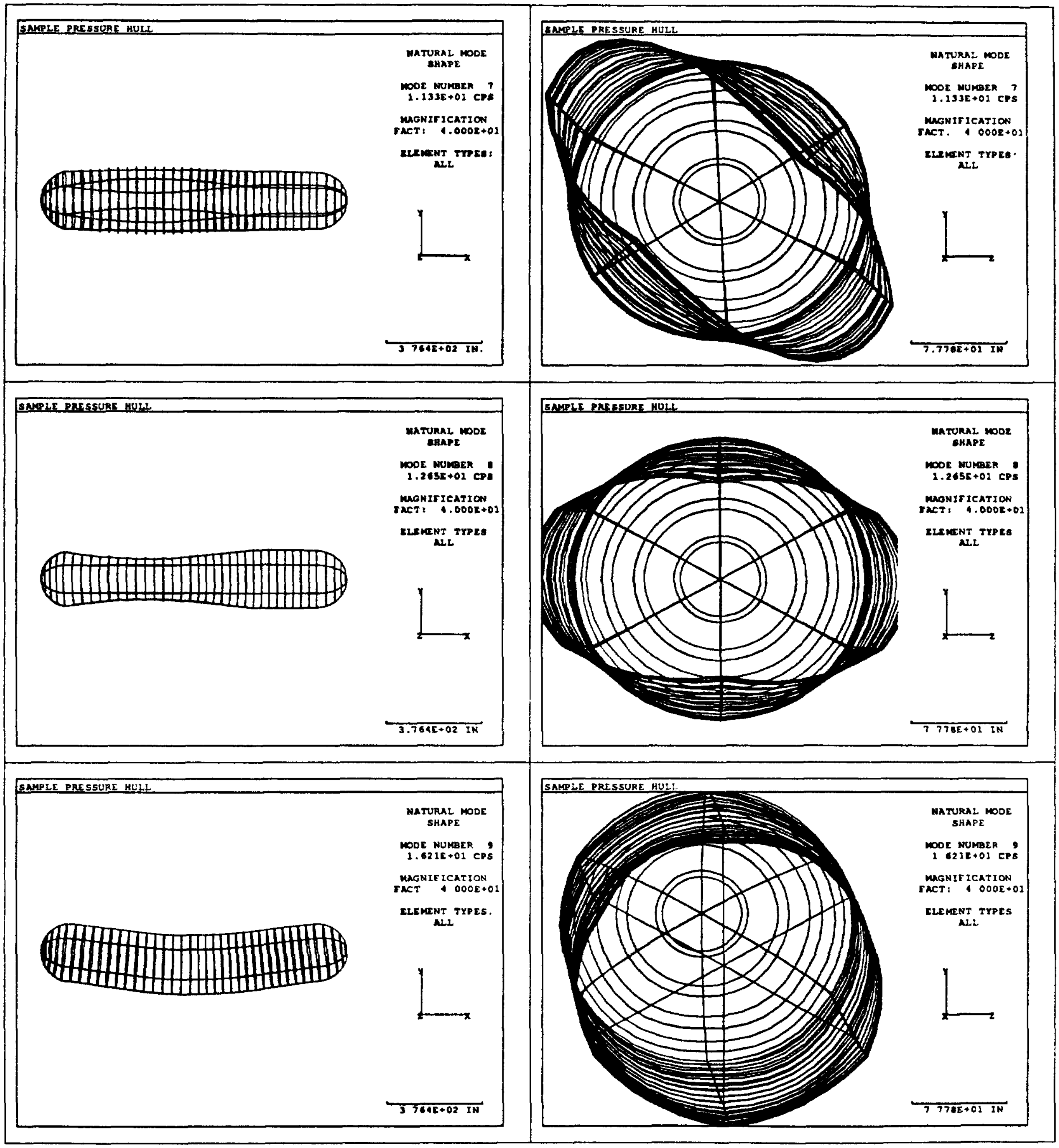


Figure 9.13 In Water Frequencies for Modes 7 to 9 for the Pressure Hull Obtained with the Panel Fluid Model

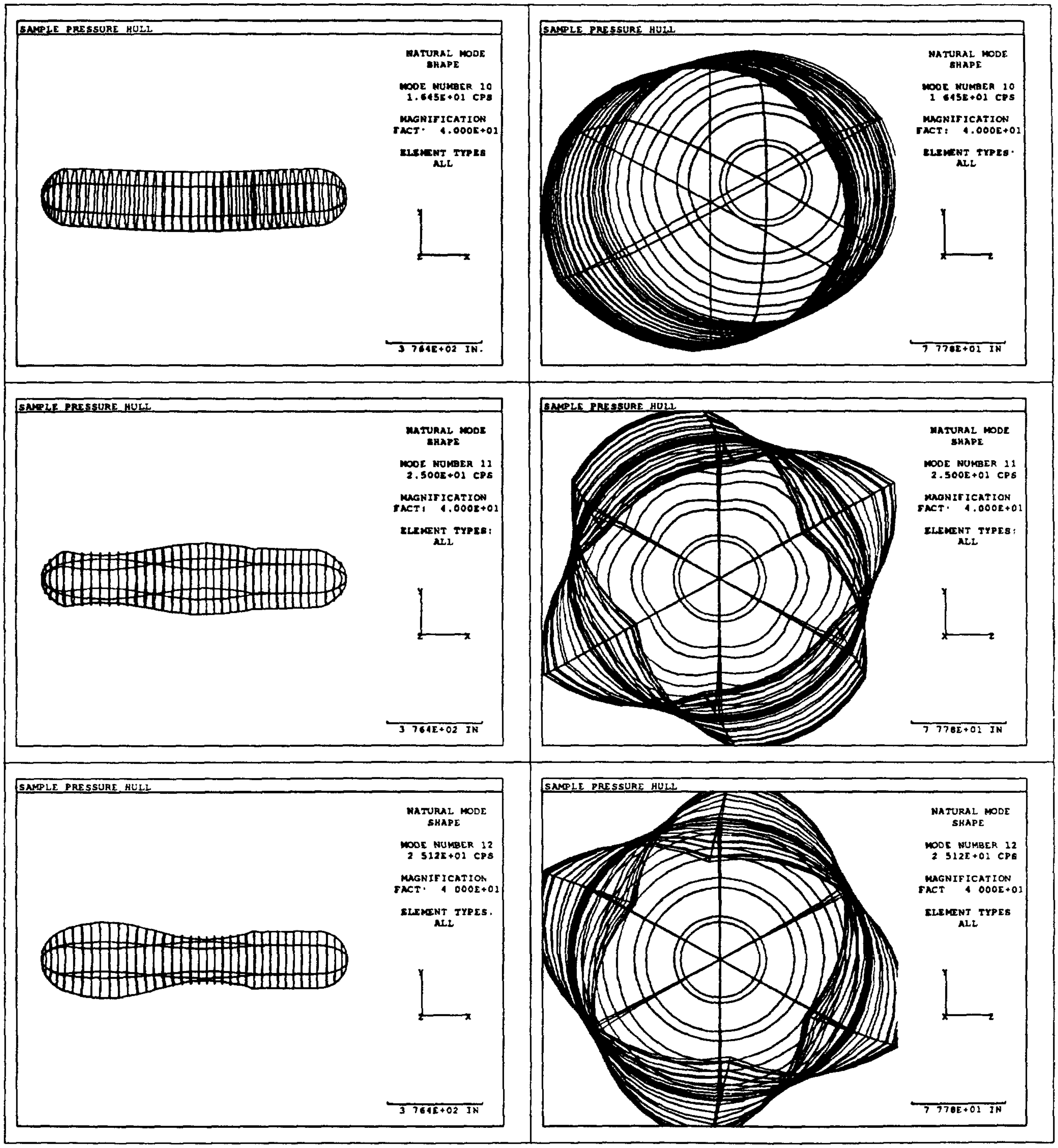


Figure 9.14 In Water Frequencies for Mode 10 to 12 for the Pressure Hull Obtained with the Panel Fluid Model

CHAPTER 10

10. PROGRAM INSTALLATION

The program is designed to run on Tektronix terminals with PLOT10 graphics. The procedure for installing SUBHUL on a VAX computer with the VMS operating system is as follows.

Input Tape Requirements

VAX backup format
9 track
6250 bpi

Load Command
SUBHUL uses the following programs and files which should be included on the input tape.

SUBHUL.FOR
SUBHUL.PAR
SUBHUL.ICM
SUBHUL.DIM
PLOTV1
PLOTV
PLOTVX
MARLIB
VASTBC

A command file should be made up in accordance with the following format assuming all the auxiliary programs are in the same directory.

```
FOR/NOOPT SUBHUL.FOR
FOR/NOOPT PLOTV1.SR5
FOR/NOOPT PLOTV.SR6
FOR/NOOPT PLOTVX.SR6
FOR/NOOPT VASTBC.SR7
FOR/NOOPT DIALOG.SUB
FOR/NOOPT MARLIB.SR6
LINK SUBHUL,PLOTV1,VASTBC,PLOTV,PLOTVX,MARLIB,DIALOG,
PLOT10/LIB
```

The suffixes on the program names may differ from those listed depending on the latest versions in use.

APPENDIX A

Basic Data File

```
 1  ISAIL
SAMPLE PRESSURE HULL
 1    1  UNITS
 1
 3 NUMBER OF DIAMETERS
 1       240.00        0.00
 2       250.00      500.00
 3       240.00     1000.00
   1.00
   1.00
 125.00    120.00 BOW AND STERN END CAP RADII
   1.00      1.00  BOW ENDCAP AND STERN ENDCAP THICKNESS
```

APPENDIX B

Model Description File (PREFX.LPR)

```
1 FILE NAME (PREFX) : SBBOT
SAMPLE PRESSURE HULL
 UNITS CHOSEN FOR DIMENSION AND FORCE = IN.  AND LBS
 AXISYMMETRIC PRESSURE HULL FORM
 NUMBER OF DIAMETERS DESCRIBING HULL FORM   3
 NO.  DIAMETER    DIST FROM HULL DATUM
  1    240.00          0.00
  2    250.00        500.00
  3    240.00       1000.00
 DIAMETER   PLATE THICKNESS
   240.00
           1.0000
   250.00
           1.0000
   240.00

 LENGTH OF PRESSURE HULL BETWEEN DOMED ENDCAPS   1000.00
 1  SPHERICAL RADIUS OF BOW DOMED ENDCAP   125.000
 2  SPHERICAL RADIUS OF STERN DOMED ENDCAP   120.000
 THICKNESS OF BOW DOMED ENDCAP     1.0000
 THICKNESS OF STERN DOMED ENDCAP     1.0000

 NUMBER OF CIRCUMFERENTIAL ELEMENTS=  6

 FULL CYLINDER MODEL ITYPE= 2

 NUMBER OF BULKHEADS=   1
 BULKHEAD LOCATION   BULKHEAD THICKNESS
        750.00           1.0000
 NO.     FLANGE  THICK     WEB     THICK    WIDTH     DEPTH   NEUT AXIS
  1        8.00    1.00    20.00    0.50     0.77     23.44     14.67
  2        5.00    1.00    10.00    0.50     0.84     11.88      7.75
  3        8.00    1.00    20.00    0.50     0.77     23.44     14.67
 FLANGE WIDTH  THICKNESS  WEB DEPTH   THICKNESS
   5.00       1.00      10.0    0.500

 SHELL CURVED BEAM STIFFNERS
    WIDTH    DEPTH   OFFSET MOMENT OF INERTIA
   1  0.77   23.44  -15.17    824.0
   2  0.84   11.88   -8.25    117.7
   3  0.84   11.88   -8.25    117.7
   4  0.84   11.88   -8.25    117.7
   5  0.84   11.88   -8.25    117.7
   6  0.84   11.88   -8.25    117.7
   7  0.84   11.88   -8.25    117.7
   8  0.84   11.88   -8.25    117.7
   9  0.84   11.88   -8.25    117.7
```

10	0.84	11.88	-8.25	117.7
11	0.84	11.88	-8.25	117.7
12	0.84	11.88	-8.25	117.7
13	0.84	11.88	-8.25	117.7
14	0.84	11.88	-8.25	117.7
15	0.77	23.44	-15.17	824.0

NUMBER OF AXIAL ELEMENTS	SPACE
14	500.000
8	250.000
8	250.000

NUMBER OF AXIAL ELEMENTS IN A END CAP 5
OVERALL LENGTH 1209.99

SHELL ELEMENT DISPLACEMENT NODE CONNECTIVITY
NUMBER OF ELEMENTS= 240

1	19	21	3	13	20	14	2
3	21	23	5	14	22	15	4
5	23	25	7	15	24	16	6
7	25	27	9	16	26	17	8
9	27	29	11	17	28	18	10
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111	129	131	113	122	130	123	112

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497	522	512	487	511	523	506	498
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518	536	538	520	527	537	528	519
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530	548	550	532	542	549	543	531
532	550	552	534	543	551	544	533
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536	554	556	538	545	555	546	537
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540	558	548	530	547	559	542	541
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550	568	570	552	561	569	562	551
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554	572	574	556	563	573	564	555
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622	640	642	624	633	641	634	623
624	642	644	626	634	643	635	625
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640	658	660	642	651	659	652	641
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656	674	676	658	668	675	669	657
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692	710	712	694	704	711	705	693
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696	714	716	698	706	715	707	697
698	716	718	700	707	717	708	699
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702	720	710	692	709	721	704	703
710	728	730	712	722	729	723	711
712	730	732	714	723	731	724	713
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716	734	736	718	725	735	726	717
718	736	738	720	726	737	727	719
720	738	728	710	727	739	722	721

BEAM ELEMENTS
NUMBER OF ELEMENTS= 90

1	91	93	92
2	93	95	94
3	95	97	96
4	97	99	98
5	99	101	100
6	101	91	102
7	127	129	128
8	129	131	130
9	131	133	132
10	133	135	134
11	135	137	136
12	137	127	138

13	163	165	164
14	165	167	166
15	167	169	168
16	169	171	170
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18	173	163	174
19	199	201	200
20	201	203	202
21	203	205	204
22	205	207	206
23	207	209	208
24	209	199	210
25	235	237	236
26	237	239	238
27	239	241	240
28	241	243	242
29	243	245	244
30	245	235	246
31	271	273	272
32	273	275	274
33	275	277	276
34	277	279	278
35	279	281	280
36	281	271	282
37	307	309	308
38	309	311	310
39	311	313	312
40	313	315	314
41	315	317	316
42	317	307	318
43	343	345	344
44	345	347	346
45	347	349	348
46	349	351	350
47	351	353	352
48	353	343	354
49	379	381	380
50	381	383	382
51	383	385	384
52	385	387	386
53	387	389	388
54	389	379	390
55	415	417	416
56	417	419	418
57	419	421	420
58	421	423	422
59	423	425	424
60	425	415	426
61	451	453	452
62	453	455	454
63	455	457	456
64	457	459	458
65	459	461	460
66	461	451	462

67	530	532	531
68	532	534	533
69	534	536	535
70	536	538	537
71	538	540	539
72	540	530	541
73	566	568	567
74	568	570	569
75	570	572	571
76	572	574	573
77	574	576	575
78	576	566	577
79	602	604	603
80	604	606	605
81	606	608	607
82	608	610	609
83	610	612	611
84	612	602	613
85	638	640	639
86	640	642	641
87	642	644	643
88	644	646	645
89	646	648	647
90	648	638	649

BULKHEAD ELEMENTS

NUMBER OF ELEMENTS= 6

487	489	505	505	488	500	505	499
489	491	505	505	490	501	505	500
491	493	505	505	492	502	505	501
493	495	505	505	494	503	505	502
495	497	505	505	496	504	505	503
497	487	505	505	498	499	505	504

NUMBER OF GEOMETRIC NODES 739
NUMBER OF DISPLACEMENT NODES 739
NUMBER OF DEGREES OF FREEDOM 3681
NUMBER OF SHELL ELEMENTS 240
NUMBER OF BEAM ELEMENTS 90
NUMBER OF BULKHEAD ELEMENTS 6
TOTAL NUMBER OF ELEMENTS 336

NODAL COORDINATES

NODE	X	Y	Z
1	-89.994	-1.200	0.000
2	-89.994	-1.039	0.600
3	-89.994	-0.600	1.039
4	-89.994	0.000	1.200
5	-89.994	0.600	1.039
6	-89.994	1.039	0.600
7	-89.994	1.200	0.000
8	-89.994	1.039	- 0.600
9	-89.994	0.600	-1.039
10	-89.994	0.000	-1.200
11	-89.994	-0.600	-1.039
12	-89.994	-1.039	-0.600
13	-88.823	-17.114	0.000

14	-88.823	-8.557	14.821
15	-88.823	8.557	14.821
16	-88.823	17.114	0.000
17	-88.823	8.557	-14.821
18	-88.823	-8.557	-14.821
19	-85.634	32.748	0.000
20	-85.634	-28.361	16.374
21	-85.634	-16.374	28.361
22	-85.634	0.000	32.748
23	-85.634	16.374	28.361
24	-85.634	28.361	16.374
25	-85.634	32.748	0.000
26	-85.634	28.361	-16.374
27	-85.634	16.374	-28.361
28	-85.634	0.000	-32.748
29	-85.634	-16.374	-28.361
30	-85.634	-28.361	-16.374
31	-80.479	-47.84	90.000
32	-80.479	-23.925	41.439
33	-80.479	23.925	41.439
34	-80.479	47.849	0.000
35	-80.479	23.925	-41.439
36	-80.479	-23.925	-41.439
37	-73.443	-62.171	0.000
38	-73.443	-53.842	31.085
39	-73.443	-31.085	53.842
40	-73.443	0.000	62.171
41	-73.443	31.085	53.842
42	-73.443	53.842	31.085
43	-73.443	62.171	0.000
44	-73.443	53.842	-31.085
45	-73.443	31.085	-53.842
46	-73.443	0.000	-62.171
47	-73.443	-31.085	3.842
48	-73.443	-53.842	-31.085
49	-64.639	-75.479	0.000
50	-64.639	-37.740	65.367
51	-64.639	37.740	65.367
52	-64.639	75.479	0.000
53	64.639	37.740	-65.367
54	-64.639	-37.740	-65.367
55	-54.211	-87.557	0.000
56	-54.211	-75.827	43.779
57	-54.211	-43.779	75.827
58	-54.211	0.000	87.557
59	-54.211	43.779	75.827
60	-54.211	75.827	43.779
61	-54.211	87.557	0.000
62	-54.211	75.827	-43.779
63	-54.211	43.779	-75.827
64	-54.211	0.000	-87.557
65	-54.211	-43.779	-75.827
66	-54.211	-75.827	-43.779
67	-42.330	-98.209	0.000

68	-42.330	-49.104	85.051
69	-42.330	49.104	85.051
70	-42.330	98.209	0.000
71	-42.330	49.104	-85.051
72	-42.330	-49.105	-85.051
73	-29.189	-107.260	0.000
74	-29.189	-92.890	53.630
75	-29.189	-53.630	92.890
76	-29.189	0.000	107.260
77	-29.189	53.630	92.890
78	-29.189	92.890	53.630
79	-29.189	107.260	0.000
80	-29.189	92.890	-53.630
81	-29.189	53.630	-92.890
82	-29.189	0.000	-107.260
83	-29.189	-53.630	-92.890
84	-29.189	-92.890	-53.630
85	-15.002	-114.564	0.000
86	-15.002	-57.282	99.215
87	-15.002	57.282	99.215
88	-15.002	114.564	0.000
89	-15.002	57.282	-99.215
90	-15.002	-57.282	-99.215
91	0.000	-120.000	0.000
92	0.000	-103.923	60.000
93	0.000	-60.000	103.923
94	0.000	0.000	120.000
95	0.000	60.000	103.923
96	0.000	103.923	60.000
97	0.000	120.000	0.000
98	0.000	103.923	-60.000
99	0.000	60.000	-103.923
100	0.000	0.000	-120.000
101	0.000	-60.000	-103.923
102	0.000	-103.923	-60.000
103	17.857	-120.351	0.000
104	17.857	-60.175	104.227
105	17.857	60.175	104.227
106	17.857	120.351	0.000
107	17.857	60.175	-104.227
108	17.857	-60.175	-104.227
109	35.714	-120.689	0.000
110	35.714	-104.520	60.344
111	35.714	-60.344	104.520
112	35.714	0.000	120.689
113	35.714	60.344	104.520
114	35.714	104.520	60.344
115	35.714	120.689	0.000
116	35.714	104.520	-60.344
117	35.714	60.344	-104.520
118	35.714	0.000	-120.689
119	35.714	-60.344	-104.520
120	35.714	-104.520	-60.344
121	53.571	-121.014	0.000

122	53.571	-60.507	104.801
123	53.571	60.507	104.801
124	53.571	121.014	0.000
125	53.571	60.507	-104.801
126	53.571	-60.507	-104.801
127	71.42	-121.327	0.000
128	71.429	-105.072	60.663
129	71.429	-60.663	105.072
130	71.429	0.000	121.327
131	71.429	60.663	105.072
132	71.429	105.072	60.663
133	71.429	121.327	0.000
134	71.429	105.072	-60.663
135	71.429	60.663	-105.072
136	71.429	0.000	-121.327
137	71.429	-60.663	-105.072
138	71.429	-105.072	-60.663
139	89.286	-121.626	0.000
140	89.286	-60.813	105.331
141	89.286	60.813	105.331
142	89.286	121.626	0.000
143	89.286	60.813	-105.331
144	89.286	-60.813	-105.331
145	107.143	-121.913	0.000
146	107.143	-105.580	60.957
147	107.143	-60.957	105.580
148	107.143	0.000	121.913
149	107.143	60.957	105.580
150	107.143	105.580	60.957
151	107.143	121.913	0.000
152	107.143	105.580	-60.957
153	107.143	60.957	-105.580
154	107.143	0.000	-121.913
155	107.143	-60.957	-105.580
156	107.143	-105.580	-60.957
157	125.000	-122.187	0.000
158	125.000	-61.094	105.817
159	125.000	61.094	105.817
160	125.000	122.187	0.000
161	125.000	61.094	-105.817
162	125.000	-61.094	-105.817
163	142.857	-122.449	0.000
164	142.857	-106.044	61.224
165	142.857	-61.224	106.044
166	142.857	0.000	122.449
167	142.857	61.224	106.044
168	142.857	106.044	61.224
169	142.857	122.449	0.000
170	142.857	106.044	-61.224
171	142.857	61.224	-106.044
172	142.857	0.000	-122.449
173	142.857	-61.224	-106.044
174	142.857	-106.044	-61.224
175	160.714	-122.698	0.000

176	160.714	-61.349	106.259
177	160.714	61.349	106.259
178	160.714	122.698	0.000
179	160.714	61.349	-106.259
180	160.714	-61.349	-106.259
181	178.571	-122.934	0.000
182	178.571	-106.464	61.467
183	178.571	-61.467	106.464
184	178.571	0.000	122.934
185	178.571	61.467	106.464
186	178.571	106.464	61.467
187	178.571	122.934	0.000
188	178.571	106.464	-61.467
189	178.571	61.467	-106.464
190	178.571	0.000	-122.934
191	178.571	-61.467	-106.464
192	78.571	-106.464	-61.467
193	196.429	-123.157	0.000
194	196.429	-61.578	106.657
195	196.429	61.578	106.657
196	196.429	123.157	0.000
197	196.429	61.578	-106.657
198	196.429	-61.578	-106.657
199	214.286	-123.367	0.000
200	214.286	-106.839	61.684
201	214.286	-61.684	106.839
202	214.286	0.000	123.367
203	214.286	61.684	106.839
204	214.286	106.839	61.684
205	214.286	123.367	0.000
206	214.286	106.839	-61.684
207	214.286	61.684	-106.839
208	214.286	0.000	-123.367
209	214.286	-61.684	-106.839
210	214.286	-106.839	-61.684
211	232.143	-123.565	0.000
212	232.143	-61.782	107.010
213	232.143	61.782	107.010
214	232.143	123.565	0.000
215	232.143	61.782	-107.010
216	232.143	-61.782	-107.010
217	250.000	-123.750	0.000
218	250.000	-107.171	61.875
219	250.000	-61.875	107.171
220	250.000	0.000	123.750
221	250.000	61.875	107.171
222	250.000	107.171	61.875
223	250.000	123.750	0.000
224	250.000	107.171	-61.875
225	250.000	61.875	-107.171
226	250.000	0.000	-123.750
227	250.000	-61.875	-107.171
228	250.000	-107.171	-61.875
229	267.857	-123.922	0.000

230	267.857	-61.961	107.320
231	267.857	61.961	107.320
232	267.857	123.922	0.000
233	267.857	61.961	-107.320
234	267.857	-61.961	-107.320
235	285.714	-124.082	0.000
236	285.714	-107.458	62.041
237	285.714	-62.041	107.458
238	285.714	0.000	124.082
239	285.714	62.041	107.458
240	285.714	107.458	62.041
241	285.714	124.082	0.000
242	285.714	107.458	-62.041
243	285.714	62.041	-107.458
244	285.714	0.000	-124.082
245	285.714	-62.041	-107.458
246	285.714	-107.458	-62.041
247	303.571	-124.228	0.000
248	303.571	-62.114	107.585
249	303.571	62.114	107.585
250	303.571	124.228	0.000
251	303.571	62.114	-107.585
252	303.571	-62.114	-107.585
253	321.429	-124.362	0.000
254	321.429	-107.701	62.181
255	321.429	-62.181	107.701
256	321.429	0.000	124.362
257	321.429	62.181	107.701
258	321.429	107.701	62.181
259	321.429	124.362	0.000
260	321.429	107.701	-62.181
261	321.429	62.181	-107.701
262	321.429	0.000	-124.362
263	321.429	-62.181	-107.701
264	321.429	-107.701	-62.181
265	339.286	-124.483	0.000
266	339.286	-62.242	107.806
267	339.286	62.242	107.806
268	339.286	124.483	0.000
269	339.286	62.242	-107.806
270	339.286	-62.242	-107.806
271	357.143	-124.592	0.000
272	357.143	-107.900	62.296
273	357.143	-62.296	107.900
274	357.143	0.000	124.592
275	357.143	62.296	107.900
276	357.143	107.900	62.296
277	357.143	124.592	0.000
278	357.143	107.900	-62.296
279	357.143	62.296	-107.900
280	357.143	0.000	-124.592
281	357.143	-62.296	-107.900
282	357.143	-107.900	-62.296
283	375.000	-124.687	0.000

284	375.000	-62.344	107.983
285	375.000	62.344	107.983
286	375.000	124.687	0.000
287	375.000	62.344	-107.983
288	375.000	-62.344	-107.983
289	392.857	-124.770	0.000
290	392.857	-108.054	62.385
291	392.857	-62.385	108.054
292	392.857	0.000	124.770
293	392.857	62.385	108.054
294	392.857	108.054	62.385
295	392.857	124.770	0.000
296	392.857	108.054	-62.385
297	392.857	62.385	-108.054
298	392.857	0.000	-124.770
299	392.857	-62.385	-108.054
300	392.857	-108.054	-62.385
301	410.714	-124.841	0.000
302	410.714	-62.420	108.115
303	410.714	62.420	108.115
304	410.714	124.841	0.000
305	410.714	62.420	-108.115
306	410.714	-62.420	-108.115
307	428.571	-124.898	0.000
308	428.571	-108.165	62.449
309	428.571	-62.449	108.165
310	428.571	0.000	124.898
311	428.571	62.449	108.165
312	428.571	108.165	62.449
313	428.571	124.898	0.000
314	428.571	108.165	-62.449
315	428.571	62.449	-108.165
316	428.571	0.000	-124.898
317	428.571	-62.449	-108.165
318	428.571	-108.165	-62.449
319	446.429	-124.943	0.000
320	446.429	-62.471	108.203
321	446.429	62.471	108.203
322	446.429	124.943	0.000
323	446.429	62.471	-108.203
324	446.429	-62.471	-108.203
325	464.286	-124.974	0.000
326	464.286	-108.23	162.487
327	464.286	-62.487	108.231
328	464.286	0.000	124.974
329	464.286	62.487	108.231
330	464.286	108.231	62.487
331	464.286	124.974	0.000
332	464.286	108.231	-62.487
333	464.286	62.487	-108.231
334	464.286	0.000	-124.974
335	464.286	-62.487	-108.231
336	464.286	-108.231	-62.487
337	482.143	-124.994	0.000

338	482.143	-62.497	108.248
339	482.143	62.497	108.248
340	482.143	124.994	0.000
341	482.143	62.497	-108.248
342	482.143	-62.497	-108.248
343	500.000	-125.000	0.000
344	500.000	-108.253	62.500
345	500.000	-62.500	108.253
346	500.000	0.000	125.000
347	500.000	62.500	108.253
348	500.000	108.253	62.500
349	500.000	125.000	0.000
350	500.000	108.253	-62.500
351	500.000	62.500	-108.253
352	500.000	0.000	-125.000
353	500.000	-62.500	-108.253
354	500.000	-108.253	-62.500
355	515.625	-124.995	0.000
356	515.625	-62.498	108.249
357	515.625	62.498	108.249
358	515.625	124.995	0.000
359	515.625	62.498	-108.249
360	515.625	-62.498	-108.249
361	531.250	-124.980	0.000
362	531.250	-108.236	62.490
363	531.250	-62.490	108.236
364	531.250	0.000	124.980
365	531.250	62.490	108.236
366	531.250	108.236	62.490
367	531.250	124.980	0.000
368	531.250	108.236	-62.490
369	531.250	62.490	-108.236
370	531.250	0.000	-124.980
371	531.250	-62.490	-108.236
372	531.250	-108.236	-62.490
373	546.875	-124.956	0.000
374	546.875	-62.478	108.215
375	546.875	62.478	108.215
376	546.875	124.956	0.000
377	546.875	62.478	-108.215
378	546.875	-62.478	-108.215
379	562.500	-124.922	0.000
380	562.500	-108.186	62.461
381	562.500	-62.461	108.186
382	562.500	0.000	124.922
383	562.500	62.461	108.186
384	562.500	108.186	62.461
385	562.500	124.922	0.000
386	562.500	108.186	-62.461
387	562.500	62.461	-108.186
388	562.500	0.000	-124.922
389	562.500	-62.461	-108.186
390	562.500	-108.186	-62.461
391	578.125	-124.878	0.000

392	578.125	-62.439	108.147
393	578.125	62.439	108.147
394	578.125	124.878	0.000
395	578.125	62.439	-108.147
396	578.125	-62.439	-108.147
397	593.750	-124.824	0.000
398	593.750	-108.101	62.412
399	593.750	-62.412	108.101
400	593.750	0.000	124.824
401	593.750	62.412	108.101
402	593.750	108.101	62.412
403	593.750	124.824	0.000
404	593.750	108.101	-62.412
405	593.750	62.412	-108.101
406	593.750	0.000	-124.824
407	593.750	-62.412	-108.101
408	593.750	-108.101	-62.412
409	609.375	-124.761	0.000
410	609.375	-62.380	108.046
411	609.375	62.380	108.046
412	609.375	124.761	0.000
413	609.375	62.380	-108.046
414	609.375	-62.380	-108.046
415	625.000	-124.687	0.000
416	625.000	-107.983	62.344
417	625.000	-62.344	107.983
418	625.000	0.000	124.687
419	625.000	62.344	107.983
420	625.000	107.983	62.344
421	625.000	124.687	0.000
422	625.000	107.983	-62.344
423	625.000	62.344	-107.983
424	625.000	0.000	-124.687
425	625.000	-62.344	-107.983
426	625.000	-107.983	-62.344
427	640.625	-124.604	0.000
428	640.625	-62.302	107.911
429	640.625	62.302	107.911
430	640.625	124.604	0.000
431	640.625	62.302	-107.911
432	640.625	-62.302	-107.911
433	656.250	-124.512	0.000
434	656.250	-107.830	62.256
435	656.250	-62.256	107.830
436	656.250	0.000	124.512
437	656.250	62.256	107.830
438	656.250	107.830	62.256
439	656.250	124.512	0.000
440	656.250	107.830	-62.256
441	656.250	62.256	-107.830
442	656.250	0.000	-124.512
443	656.250	-62.256	-107.830
444	656.250	-107.830	-62.256
445	671.875	-124.409	0.000

446	671.875	-62.205	107.741
447	671.875	62.205	107.741
448	671.875	124.409	0.000
449	671.875	62.205	-107.741
450	671.875	-62.205	-107.741
451	687.500	-124.297	0.000
452	687.500	-107.644	62.148
453	687.500	-62.148	107.644
454	687.500	0.000	124.297
455	687.500	62.148	107.644
456	687.500	107.644	62.148
457	687.500	124.297	0.000
458	687.500	107.644	-62.148
459	687.500	62.148	-107.644
460	687.500	0.000	-124.297
461	687.500	-62.148	-107.644
462	687.500	-107.644	-62.148
463	703.125	-124.175	0.000
464	703.125	-62.087	107.538
465	703.125	62.087	107.538
466	703.125	124.175	0.000
467	703.125	62.087	-107.538
468	703.125	-62.087	-107.538
469	718.750	-124.043	0.000
470	718.750	-107.424	62.021
471	718.750	-62.021	107.424
472	718.750	0.000	124.043
473	718.750	62.021	107.424
474	718.750	107.424	62.021
475	718.750	124.043	0.000
476	718.750	107.424	-62.021
477	718.750	62.021	-107.424
478	718.750	0.000	-124.043
479	718.750	-62.021	-107.424
480	718.750	-107.424	-62.021
481	734.375	-123.901	0.000
482	734.375	-61.951	107.302
483	734.375	61.951	107.302
484	34.375	123.901	0.000
485	734.375	61.951	-107.302
486	734.375	-61.951	-107.302
487	750.000	-123.750	0.000
488	750.000	-107.171	61.875
489	750.000	-61.875	107.171
490	750.000	0.000	123.750
491	750.000	61.875	107.171
492	750.000	107.171	61.875
493	750.000	123.750	0.000
494	750.000	107.171	-61.875
495	750.000	61.875	-107.171
496	750.000	0.000	-123.750
497	750.000	-61.875	-107.171
498	750.000	-107.171	-61.875
499	750.000	-61.875	0.000

500	750.000	-30.937	53.585
501	750.000	30.937	53.585
502	750.000	61.875	0.000
503	750.000	30.937	-53.585
504	750.000	-30.937	-53.585
505	750.000	0.000	0.000
506	765.625	-123.589	0.000
507	765.625	-61.794	107.031
508	765.625	61.794	107.031
509	765.625	123.589	0.000
510	765.625	61.794	-107.031
511	765.625	-61.794	-107.031
512	781.250	-123.418	0.000
513	781.250	-106.883	61.709
514	781.250	-61.709	106.883
515	781.250	0.000	123.418
516	781.250	61.709	106.883
517	781.250	106.883	61.709
518	781.250	123.418	0.000
519	781.250	106.883	-61.709
520	781.250	61.709	-106.883
521	781.250	0.000	-123.418
522	781.250	-61.709	-106.883
523	781.250	-106.883	-61.709
524	796.875	-123.237	0.000
525	796.875	-61.619	106.727
526	796.875	61.619	106.727
527	796.875	123.237	0.000
528	796.875	61.619	-106.727
529	796.875	-61.619	-106.727
530	812.500	-123.047	0.000
531	812.500	-106.562	61.523
532	812.500	-61.523	106.562
533	812.500	0.000	123.047
534	812.500	61.523	106.562
535	812.500	106.562	61.523
536	812.500	123.047	0.000
537	812.500	106.562	-61.523
538	812.500	61.523	-106.562
539	812.500	0.000	-123.047
540	812.500	-61.523	-106.562
541	812.500	-106.562	-61.523
542	828.125	-122.847	0.000
543	828.125	-61.423	106.388
544	828.125	61.423	106.388
545	828.125	122.847	0.000
546	828.125	61.423	-106.388
547	828.125	-61.423	-106.388
548	843.750	-122.637	0.000
549	843.750	-106.206	61.318
550	843.750	-61.318	106.206
551	843.750	0.000	122.637
552	843.750	61.318	106.206
553	843.750	106.206	61.318

554	843.750	122.637	0.000
555	843.750	106.206	-61.318
556	843.750	61.318	-106.206
557	843.750	0.000	-122.637
558	843.750	-61.318	-106.206
559	843.750	-106.206	-61.318
560	859.375	-122.417	0.000
561	859.375	-61.208	106.016
562	859.375	61.208	106.016
563	859.375	122.417	0.000
564	859.375	61.208	-106.016
565	859.375	-61.208	-106.016
566	875.000	-122.187	0.000
567	875.000	-105.817	61.094
568	875.000	-61.094	105.817
569	875.000	0.000	122.187
570	875.000	61.094	105.817
571	875.000	105.817	61.094
572	875.000	122.187	0.000
573	875.000	105.817	-61.094
574	875.000	61.094	-105.817
575	875.000	0.000	-122.187
576	875.000	-61.094	-105.817
577	875.000	-105.817	-61.094
578	890.625	-121.948	0.000
579	890.625	-60.974	105.610
580	890.625	60.974	105.610

581	890.625	121.948	0.000
582	890.625	60.974	-105.610
583	890.625	-60.974	-105.610
584	906.250	-121.699	0.000
585	906.250	-105.395	60.850
586	906.250	-60.850	105.395
587	906.250	0.000	121.699
588	906.250	60.850	105.395
589	906.250	105.395	60.850
590	906.250	121.699	0.000
591	906.250	105.395	-60.850
592	906.250	60.850	-105.395
593	906.250	0.000	-121.699
594	906.250	-60.850	-105.395
595	906.250	-105.395	-60.850
596	921.875	-121.440	0.000
597	921.875	-60.720	105.170
598	921.875	60.720	105.170
599	921.875	121.440	0.000
600	921.875	60.720	-105.170
601	921.875	-60.720	-105.170
602	937.500	-121.172	0.000
603	937.500	-104.938	60.586
604	937.500	-60.586	104.938
605	937.500	0.000	121.172
606	937.500	60.586	104.938
607	937.500	104.938	60.586
608	937.500	121.172	0.000
609	937.500	104.938	-60.586
610	937.500	60.586	-104.938
611	937.500	0.000	-121.172
612	937.500	-60.586	-104.938
613	937.500	-104.938	-60.586
614	953.125	-120.894	0.000
615	953.125	-60.447	104.697
616	953.125	60.447	104.697
617	953.125	120.894	0.000
618	953.125	60.447	-104.697
619	953.125	-60.447	-104.697
620	968.750	-120.605	0.000
621	968.750	-104.447	60.303
622	968.750	-60.303	104.447
623	968.750	0.000	120.605
624	968.750	60.303	104.447
625	968.750	104.447	60.303
626	968.750	120.605	0.000
627	968.750	104.447	-60.303
628	968.750	60.303	-104.447
629	968.750	0.000	-120.605
630	968.750	-60.303	-104.447
631	968.750	-104.447	-60.303
632	984.375	-120.308	0.000
633	984.375	-60.154	104.189
634	984.375	60.154	104.189

635	984.375	120.308	0.000
636	984.375	60.154	-104.189
637	984.375	-60.154	-104.189
638	1000.000	-120.000	0.000
639	1000.000	-103.923	60.000
640	1000.000	-60.000	103.923
641	1000.000	0.000	120.000
642	1000.000	60.000	103.923
643	1000.000	103.923	60.000
644	1000.000	120.000	0.000
645	1000.000	103.923	-60.000
646	1000.000	60.000	-103.923
647	1000.000	0.000	-120.000
648	1000.000	-60.000	-103.923
649	1000.000	-103.923	-60.000
650	1018.654	-118.541	0.000
651	1018.654	-59.271	102.660
652	1018.654	59.271	102.660
653	1018.654	118.541	0.000
654	1018.654	59.271	-102.660
655	1018.654	-59.271	-102.660
656	1036.854	-114.201	0.000
657	1036.854	-98.901	57.100
658	1036.854	-57.100	98.901
659	1036.854	0.000	114.201
660	1036.854	57.100	98.901
661	1036.854	98.901	57.100
662	1036.854	114.201	0.000
663	1036.854	98.901	-57.100
664	1036.854	57.100	-98.901
665	1036.854	0.000	-114.201
666	1036.854	-57.100	-98.901
667	1036.854	-98.901	-57.100
668	1054.158	-107.084	0.000
669	1054.158	-53.542	92.737
670	1054.158	53.542	92.737
671	1054.158	107.084	0.000
672	1054.158	53.542	-92.737
673	1054.158	-53.542	-92.737
674	1070.145	-97.363	0.000
675	1070.145	-84.319	48.682
676	1070.145	-48.682	84.319
677	1070.145	0.000	97.363
678	1070.145	48.682	84.319
679	1070.145	84.319	48.682
680	1070.145	97.363	0.000
681	1070.145	84.319	-48.682
682	1070.145	48.682	-84.319
683	1070.145	0.000	-97.363
684	1070.145	-48.682	-84.319
685	1070.145	-84.319	-48.682
686	1084.427	-85.276	0.000
687	1084.427	42.638	73.851
688	1084.427	42.638	73.851

689	1084.427	85.276	0.000
690	1084.427	42.638	-73.851
691	1084.427	-42.638	-73.851
692	1096.657	-71.115	0.000
693	1096.657	-61.588	35.558
694	1096.657	-35.558	61.588
695	1096.657	0.000	71.115
696	1096.657	35.558	61.588
697	1096.657	61.588	35.558
698	1096.657	71.115	0.000
699	1096.657	61.588	-35.558
700	1096.657	35.558	-61.588
701	1096.657	0.000	-71.115
702	1096.657	-35.558	-61.588
703	1096.657	-61.588	-35.558
704	1106.537	-55.226	0.000
705	1106.537	-27.613	47.827
706	1106.537	27.613	47.827
707	1106.537	55.226	0.000
708	1106.537	27.613	-47.827
709	1106.537	-27.613	-47.827
710	1113.826	-37.994	0.000
711	1113.826	-32.904	18.997
712	1113.826	-18.997	32.904
713	1113.826	0.000	37.994
714	1113.826	18.997	32.904
715	1113.826	32.904	18.997
716	1113.826	37.994	0.000
717	1113.826	32.904	-18.997
718	1113.826	18.997	-32.904
719	1113.826	0.000	-37.994
720	1113.826	-18.997	-32.904
721	1113.826	-32.904	-18.997
722	1118.349	-19.838	0.000
723	1118.349	-9.919	17.180
724	1118.349	9.919	17.180
725	1118.349	19.838	0.000
726	1118.349	9.919	-17.180
727	1118.349	-9.919	-17.180
728	1119.994	-1.200	0.000
729	1119.994	-1.039	0.600
730	1119.994	-0.600	1.039
731	1119.994	0.000	1.200
732	1119.994	0.600	1.039
733	1119.994	1.039	0.600
734	1119.994	1.200	0.000
735	1119.994	1.039	-0.600
736	1119.994	0.600	-1.039
737	1119.994	0.000	-1.200
738	1119.994	-0.600	-1.039
739	1119.994	-1.039	-0.600

BOUNDARY CONDITIONS FILE GENERATION PROGRAM FOR VAST

VASTBC

USER'S MANUAL

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Halifax Insurance Building, Suite 805
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B3J 1H6

November 1989

VASTBC

VASTBC plots structural finite element models from VAST input data files and allows the user to define new or to edit existing boundary condition data interactively using the graphics cursor.

The operation of the program is very similar to the VAST-G program, PLOTV1, and hence offers the user much control over what is shown on the plot. The initial operation of VASTBC proceeds as PLOTV1 with the user specifying nodes to be plotted, elements to be plotted, viewing parameters and various other specifications. Boundary conditions may be indicated if they are contained on the data file or may be plotted after they are generated.

VASTBC differs from PLOTV1 in the operation of the program following the appearance of the plot. The right hand side of the plot is reserved for the display of the legend containing the instructions for the next step of operation. The current options available in VASTBC are shown in Figure 1 and are activated from the graphics cursor and keyboard. A dialog area/message area is reserved at the bottom of the plot for data entry and prompting.

Because VASTBC is plotting VAST input data which may exist in a number of different files, the input files required are not always the same. The structural data will be contained in either the PREFX.USE or PREFX.GOM files. In the case that there are no substructures/superelements, VASTBC will operate properly with only the PREFX.GOM file. However, in this case original boundary conditions, if present, cannot be plotted or modified. If there are substructures, superelements, or original boundary conditions, PREFX.USE must be present with the necessary data to plot these features.

The execution of VASTBC results in the creation of a PREFX.SMD file containing the boundary condition data as specified through interactive prompting for nodal points selected using the graphics cursor. The nodal points may be selected individually or multiply. If the model contains substructures/superelements, then the application of a boundary condition to a node not specified as a master node will result in the superelement data being revised to reflect this change.

Operating Instructions for Program VASTBC

Files Required: PREFX.USE, PREFX.GOM, PREFX.SED, PREFX.SMD

Terminal Response:
(Note: all input is in free format unless otherwise specified.)

(1) PROGRAM VASTBC: VAST GRAPHICS PROGRAM FOR GENERATING/MODIFING
BOUNDARY CONDITIONS FOR FINITE ELEMENT MODELS

(2) ENTER VAST FILE NAME PREFX

The user inputs the VAST file name 'PREFX'. This is the prefix name which identified the data file sets, and may be up to 5 characters long. VASTBC searches for the data files with the specified prefix name.

(3) WHAT IS THE LINE SPEED?

This prompt is omitted if PC version of program.

The user should enter the baud rate at which the terminal is communicating with the host computer.

(4) IDENTIFY TERMINAL TYPE ACCORDING TO RESOLUTION, CURSOR AND COLOUR CAPABILITY:
ENTER 0 FOR TEKTRONIX 4006 OR EQUAL (LOW RES/NO CURS/NO COL)
1 FOR TEKTRONIX 401* OR EQUAL (LOW RES/CURSORS/NO COL)
2 FOR TEKTRONIX 4014/15 (HI RES/CURSORS/NO COL)
3 FOR TEKTRONIX 4113 OR EQUAL (COLOUR):

This prompt is omitted if PC version of program.

The user should enter a 1, 2 or 3 according to the type of features the terminal supports. The user should avoid responding with '3' as colour graphics have not yet been reliably incorporated into VASTBC. VASTBC requires cursor capability and if a '0' is entered the program will terminate.

(5) IDENTIFY TERMINAL TYPE ACCORDING TO DIALOG CAPABILITY:
ENTER 0 IF NO DIALOG
1 DIALOG

This prompt is omitted if PC version of program.

(6) ENTER 0 FOR VIEWING VECTOR APPROACH
OR 1 FOR FINITE ANGULAR ROTATIONS:

The user defines which viewing approach is desired. See the section in the VASTG manual [1] on view specifications for a description of the two different approaches (prompts 21 and 22).

(7) ENTER 0 TO GENERATE NEW BOUNDARY CONDITION DATA
OR 1 TO MODIFY EXISTING BOUNDARY CONDITION DATA

This prompt is omitted if there is not any existing boundary condition data.

Statements (1) to (7) appear only once, at the beginning of each execution of VASTBC. The parameters specified in response to these prompts may only be changed by restarting VASTBC. The remaining input specifications may be modified when running VASTBC and are divided into three sections, (1) PLOT specifications, (2) VIEW specifications, (3) CURSOR options.

(8) * PLOT SPECIFICATIONS *

(9) DO YOU WANT TO PLOT ANY NODES? (0=NO):

If the user wants any nodes identified on the plot, a non-zero response should be entered. If the user enters 0, prompts (10) to (14) are omitted.

(10) ENTER NUMBER OF SUPERELEMENT FOR NODE PLOTTING
(0 FOR SAME OPTIONS AS PREVIOUS SUPERELEMENT
=0 TO TERMINATE NODE PLOTTING SPECIFICATIONS
0 TO SPECIFY NODE PLOTTING OPTIONS):

This prompt is omitted if there are no substructures/superelements. Otherwise, the user specifies which superelement is to have nodes plotted. The superelements may be specified in any order and a superelement may be specified more than once, but only the latest specifications for a given superelement are retained. The first superelement specification must not be negative, but on subsequent superelement specifications, a negative entry indicates that the same node plotting options as for the previous superelement are used and hence prompts (11)-(14) are omitted.

(11) THERE ARE III GEOMETRIC NODES.

This information is provided for the user's reference. In the case that there are substructures/superelements, this information applies to the specified superelements.

(12) ENTER FIRST & LAST NODES TO BE NUMBERED & INCREMENT
(ENTER 1,-1,1 TO NUMBER ALL NODES
ENTER 0, 0,0 IF NODE NUMBERING NOT DESIRED):

If there are substructures/superelements, this prompt applies to the substructure node numbers of the particular superelement.

(13) ENTER FIRST & LAST NODES TO BE PLOTTED & SYMBOL CODE
(ENTER 1,-1,1 TO PLOT ALL NODES WITH CIRCLES
ENTER 0, 0,0 IF NODE PLOTTING NOT DESIRED):

This prompt refers to the symbol to be plotted at each node coordinate.

(14) ENTER BOUNDARY NODE OPTION CODE & SYMBOL CODE
(OPTION 0 - BOUNDARY NODES - MASTER NODE NUMBERS
=0 - NO BOUNDARY NODES
0 - BOUNDARY NODES - LOCAL NODE NUMBERS):

This prompt is omitted if there are no substructures/superelements. Otherwise, the user defines how the boundary nodes are to be plotted and numbered. Note that only the sign (+ or - or 0) of the boundary node option code is important.

If there are substructures/superelements prompt (10) and prompts (11) to (14) (if applicable), are repeated until the user terminates node plotting specifications with a 0 entry at prompt (10). If there are no substructures/superelements, prompts (11) to (14) appear once only.

(15a) DO YOU WANT A SUMMARY OF THE ELEMENTS AND GROUPS? (0=NO)

If the response is non-zero then a table is produced with format at step (15b) for substructured models and (15c) for unsubstructured models.

(15b) SUPERELEMENT NUMBER | ELEMENT GROUP | TYPE OF ELEMENTS | NUMBER OF ELEMENTS

SUPERELEMENT NUMBER	ELEMENT GROUP	TYPE OF ELEMENTS	NUMBER OF ELEMENTS
XX	XX	XX	XXX
•	•	•	•
•	•	•	•
XX	XX	XX	XXX

(15c)

ELEMENT GROUP	TYPE OF ELEMENTS	NUMBER OF ELEMENTS
XX	XX	XXX
•	•	•
•	•	•
XX	XX	XXX

(16a) DO YOU WANT ALL OF THE ELEMENTS PLOTTED? (0=NO)

This prompt is omitted if there are superelements/substructures. A non-zero response will cause all of the elements to be displayed and control to be transferred to (21). A response of zero results in control being transferred to (18).

(16b) DO YOU WANT ALL ELEMENTS OF ALL S-E'S PLOTTED? (0=NO)

This prompt is omitted if there are no superelements/substructures. A non-zero response will cause all of the elements to be displayed and control to be transferred to (21). A response of zero results in control being transferred to (17). If the user wishes all the elements of all superelements to be plotted then a non-zero response is entered and control is transferred to (21).

(17a) ENTER NUMBER OF SUPERELEMENT FOR ELEMENT PLOTTING
(<0 FOR SAME OPTIONS AS PREVIOUS SUPERELEMENT
=0 TO TERMINATE ELEMENT PLOTTING SPECIFICATIONS
>0 TO SPECIFY ELEMENT PLOTTING OPTIONS)

The user should specify which superelement is to have elements plotted. The superelements may be specified in any order and more than once but only the latest specification for a given superelement is retained. The first superelement specification must not be negative, but on subsequent superelement specifications a negative entry indicates that the same element plotting specifications as for the previous superelement are to be used and hence prompts (17) to (20) are omitted.

(17b) DO YOU WANT A SUMMARY OF THE ELEMENTS AND GROUPS? (0=NO)

If the response is non-zero then the following table is produced.

SUPERELEMENT NUMBER	ELEMENT GROUP	TYPE OF ELEMENTS	NUMBER OF ELEMENTS
XX	XX	XX	XXX
•	•	•	•
•	•	•	•
XX	XX	XX	XXX

(17c) DO YOU WANT ALL OF THE ELEMENTS PLOTTED? (0=NO)

If the user wishes all the elements to be plotted then a non-zero response is entered and control returns to (17a).

(18) ENTER 0 TO SPECIFY ELEMENTS BY GROUP AND RANGE
OR 1 TO SPECIFY ELEMENTS BY TYPE

The user response of 0 causes prompt (19) to be displayed and the entry 1 causes this prompt to be omitted and prompt (20) to be displayed.

(19) SPECIFY ELEMENT GROUP AND FIRST AND LAST ELEMENTS
TO BE PLOTTED (ENTER X,1,-1, TO PLOT ALL ELEMENTS
OF GROUP X, AND 0,0,0 TO TERMINATE)

The user specifies which element group and elements (of the specified superelement, if applicable) are to be plotted. The element groups may be specified in any order, and element groups may be specified more than once, but only the latest specified range of elements is retained. If an element group is specified which does not exist, a warning is issued and the input is ignored. Prompt (19) continues to reappear until the user enters an element plotting specification of 0,0,0. If the model is substructured then control returns to (17a).

(20a) SPECIFY ELEMENT TYPES (IEC) TO BE PLOTTED.
ALL ELEMENTS OF ALL GROUPS OF THIS TYPE
WILL BE PLOTTED. TERMINATE BY ENTERING 0.

The above prompt appears once.

(20b) ENTER ELEMENT TYPE (0 TO TERMINATE)

The user specifies which element types are to be plotted.
Prompt (20b) continues to reappear until the user enters an element type of 0. If the model is substructured, control returns to (17a). Otherwise, control is to the next step.

(21) * VIEW SPECIFICATIONS *

(21A) ENTER DIRECTION COSINES OF LINE OF VIEW,
ROTATION ANGLE, AND PLOT REDUCING FACTOR (PERCENT):

(21B) ENTER ROTATIONS ABOUT BODY FIXED AXES X, Y & Z AXES AND PLOT
REDUCING FACTOR (PERCENT):

The prompt which appears here depends on the response to (3). Prompt (21A) corresponds to the viewing vector approach and (21B) corresponds to the finite angular rotations.

The plot reducing factor defines the percentage reduction of the plot size. The plot reducing factor will be set to 30% if specified as less. This is necessary to provide space for the dialog area below the plot. The user is informed of this by the following message appearing:

"THE PLOT REDUCING FACTOR WILL BE SET TO 30 PERCENT."

(22A) ENTER ELEMENT TYPES TO BE PLOTTED
(=0 TO PLOT ALL TYPES
=1 TO SPECIFY PARTICULAR TYPES):

(22B) ENTER ELEMENT TYPE
(=0 TO TERMINATE):

This prompt is omitted if no element plotting is to be done. Otherwise, it allows the user to specify the type of elements to be plotted. Prompt (22A) appears first. If the user enters 0 in response to this prompt, all element types will be plotted and prompt (24B) is omitted. Otherwise, prompt (22A) appears, and the user enters the element type code (IEC) for the element types which are to be plotted. Only one type should be specified at a time, and prompt (22B) will appear after each entry. This cycle is terminated by entering 0.

(23) ENTER 0 TO USE ONLY ONE VIEW TO IDENTIFY WINDOWED NODES
1 TO USE RECURSIVE VIEWS TO IDENTIFY WINDOWED NODES

This prompt is necessary to determine if repeated redisplay and redefinition of the window on different views of the model are required to specify node selection using the window capability. If '0' is entered then the selection of nodes using a window allows the user to specify boundary conditions for all the nodes located within the window. If '1' is entered the user is prompted to enter a second view. The nodes to be assigned boundary conditions are the nodes common to the recursive views.

(24) DO YOU WANT THE BOUNDARY CONDITIONS INDICATED? (0=NO):

This prompt appears if boundary condition data exists. If '0' is entered in response to Prompt 7 then this prompt does not appear for the first plot. It does appear after boundary condition data is generated and the plot specifications are redefined. The boundary conditions are displayed as an XYZ coordinate axis triad at the nodes at which they are applied. Translation and rotation are represented by crosses and circles, respectively at the middle of the appropriate triad axis. Note that for some elements rotation constraints are applied about the element local axes. For clarity, VASTBC indicates the constraints about the global axis. In effect then, VASTBC indicates a constraint of degree-of-freedom four as circle about the global X axis, degree-of-freedom five about the global Y axis and degree-of-freedom six about the global Z axis.

(25) DO YOU WANT THE B.C. NODES NUMBERED? (0=NO):

This prompt appears if the boundary conditions are to be indicated. If the user replies in the affirmative, the node numbers are plotted beside the triad at each node at which boundary conditions are applied.

(26) PRESS RETURN TO PLOT

(27) *** CURSOR OPTIONS ***

The screen is first erased and the the legend is displayed on the right hand side of the screen indicating the alphanumeric keyboard entry to use for the cursor options. Next, the plot appears on the screen as specified by the responses to prompts (9) to (25). Plotting is finished when the borders and title appear. A single bell will sound to indicate that the program is expecting input. Any alphanumeric keyboard entry, followed by 'Return', or simply 'Return' will cause the screen to be cleared and control to be transferred to 29. Otherwise, the user may use the graphics cursors options described below.

GRAPHICS CURSOR OPTIONS: These options are selected by entering one of the following in response to the single bell:

I = select individual node locations
M = select multiple node locations
A = assign stiffness codes to selected nodes
L = label nodes
W = window
R = recover original plot

Any other keyboard entry, or simply 'Return', causes control to transfer to (29). These cursor options are described in the following sections. The L, W and R options are the same feature available in VAST graphics program PLOTV1.

(28A) I = Select individual nodes with cursor.

This option allows the user to select individual nodes using the graphics cursor. If the user selects this option, a bell will sound, indicating that input is expected via the graphics cursor. The user then positions the cursor near the node of interest and enters any alphanumeric keyboard character or simply 'Return'. Once the node is selected a bell will sound and the cycle is repeated. The user therefore may select several nodes individually along a curved edge. It is possible that these nodes may not be identified through the window operation. The cycle is broken when the user selects a point outside the plot (i.e. a position in the legend). The selection of such a point causes control to return to (27). The user is notified of the change in control by the following message appearing in the dialog area.

ENTER CARRIAGE RETURN AND FOLLOW LEGEND ON THE RIGHT.

The user should note that the program searches through all the node coordinate data to find the node(s) closest to the cursor position. If there are substructures/superelements, all the substructures and associated substructure numbers are recorded for the selected locations. The stiffness codes for these nodes may be assigned by entering an 'A' when control returns to (27).

(28B) M = Select multiple nodes with cursor.

This option allows the user to select multiple nodes using a window. If the user selects this option a bell will sound indicating that input is expected via the graphics cursor. The user positions the cursor at the lower left hand corner of the area to be windowed, and enters any alphanumeric character, or simply 'return'. A bell will sound and the user repositions the cursor to the upper righthand corner of the area to be windowed. A box is drawn around the area and a bell sounds. The user then enters a carriage return.

If the user has entered '0' to prompt (23) then control is transferred ahead to (28C). The user then assigns stiffness codes for the nodes windowed and control returns to (27) and the user may enter an M to define another window or I to select individual nodes. The same plot remains.

If the user entered '1' to prompt (23) then the user is prompted for a new view and the model is replotted. This allows further refinement of the node point selection as obtained by repeated redisplay and redefinition of the window, presumably on different model views. The stiffness nodes for these nodes may be assigned by entering an 'A' when control returns to (27).

(28C) A = assign stiffness codes for nodes selected.

This option allows the user to assign stiffness codes for nodes selected either individually using the cursor or multiplely using a window. The following prompts to specify this data appear in the dialog area. The user is first prompted whether the same stiffness codes are desired for all the nodes identified.

DO YOU WANT TO ASSIGN THE SAME DEGREE OF FREEDOM STIFFNESS CODES FOR ALL NODES IDENTIFIED? (0=NO, 1=YES)

The next prompt is for the user to enter the codes.

INPUT 6 CODES SPECIFYING WHICH DEGREES OF FREEDOM ARE TO BE ASSIGNED STIFFNESS.

If nodal points have been selected which already have stiffness codes assigned then the user is notified and asked if they are to be changed.

STIFFNESS CODES ALREADY SPECIFIED FOR NODE: XX
ENTER: 0=NO CHANGE, 1=NEW DATA, 2=REMOVE CONSTRAINT

The user is notified when all the nodes selected have been assigned by the following message in the display area:

ALL NODES SELECTED HAVE HAD CODES SPECIFIED INPUT A CARRIAGE RETURN. THEN FOLLOW LEGEND ON THE RIGHT.

Control returns to (27). If the model is substructured then the assigning of a boundary condition to a substructure node will result in node being made a master node if the node was not already specified as such. The super element data is updated to reflect this change.

(28D) Node Labelling.

This option allows the user to selectively number nodes using the graphics cursor. If the user selects this option, two bells will sound, indicating that input is expected via the graphics cursor. The user then positions the cursor near the node of interest and enters any alphanumeric keyboard character or simply 'Return'. If a keyboard character is entered, do not follow it with 'Return'. The program then searches through all of the node coordinate data to find the node(s) closest to the cursor position. The node position is marked with a circle, and the node number appears at the cursor position. If there are substructures/superelements, both the superelement number and associated substructure node number will appear. Once the node is numbered, two bells will sound and the cycle is repeated. The cycle is broken when the user selects a point outside the screen window. The selection of such a point causes the control to return to (27). The user is notified of the change in control by the following message appearing in the dialog area.

ENTER A CARRIAGE RETURN AND THEN FOLLOW LEGEND ON THE RIGHT.

The user should note that since the computer uses the node coordinates and cursor coordinates as real numbers, it is unlikely that it will determine any two nodes as equal distance from the cursor, even if they should be. Thus, although VASTBC will number almost any number of nodes if the computer determines they are all an equal (minimum) distance from the cursor, it will generally be difficult for the user to get more than one node number for a single cursor position.

(28E) W = Windowing.

This option allows the user to window the plot. This may be used to blow up or expand a portion of the plot, or to reduce the plot. If the user selects this option, two bells will sound, indicating that input is expected via the graphics cursor. The user positions the cursor at the lower left hand corner of the area to be windowed, and enters any alphanumeric keyboard character, or simply 'Return'. If a keyboard character is entered, do <u>not</u> follow it with return. Two bells will sound and the procedure is repeated for the upper right hand corner of the area to be windowed. A box is then drawn around the area to be windowed, and a single bell will sound. When the user enters any keyboard character followed by 'Return', or simply 'Return', control is transferred back to (27), with only the windowed portion of the plot being displayed. Note that if the user attempts to reduce the plot by windowing outside it, the box around the windowed area will not appear, as it will lie outside the present virtual coordinate limits. This usage, however, is still valid. Also, if the user has numbered the nodes selectively before windowing, these node numbers will not appear on the windowed plot, but may be renumbered again, after the plot is finished, using the technique described in (28D).

(28F) R = Recovery of original plot.

If the user selects to recover the original plot, which is the first plot which appeared after the present plot and view parameters were specified, control is transferred back to (27) and the user may therefore select another cursor option as described in the legend after the plot is completed.

(29) ENTER 0 TO TERMINATE
1 TO CHANGE VIEW SPECIFICATIONS
2 TO CHANGE PLOT SPECIFICATIONS
3 TO CHANGE ALL SPECIFICATIONS:

An entry of 1 allows only the view specifications (prompts (21) to (25)) to be changed, an entry of 2 allows only the plot specifications (prompts (8) to (20)) to be changed, and an entry of 3 allows both to be changed.

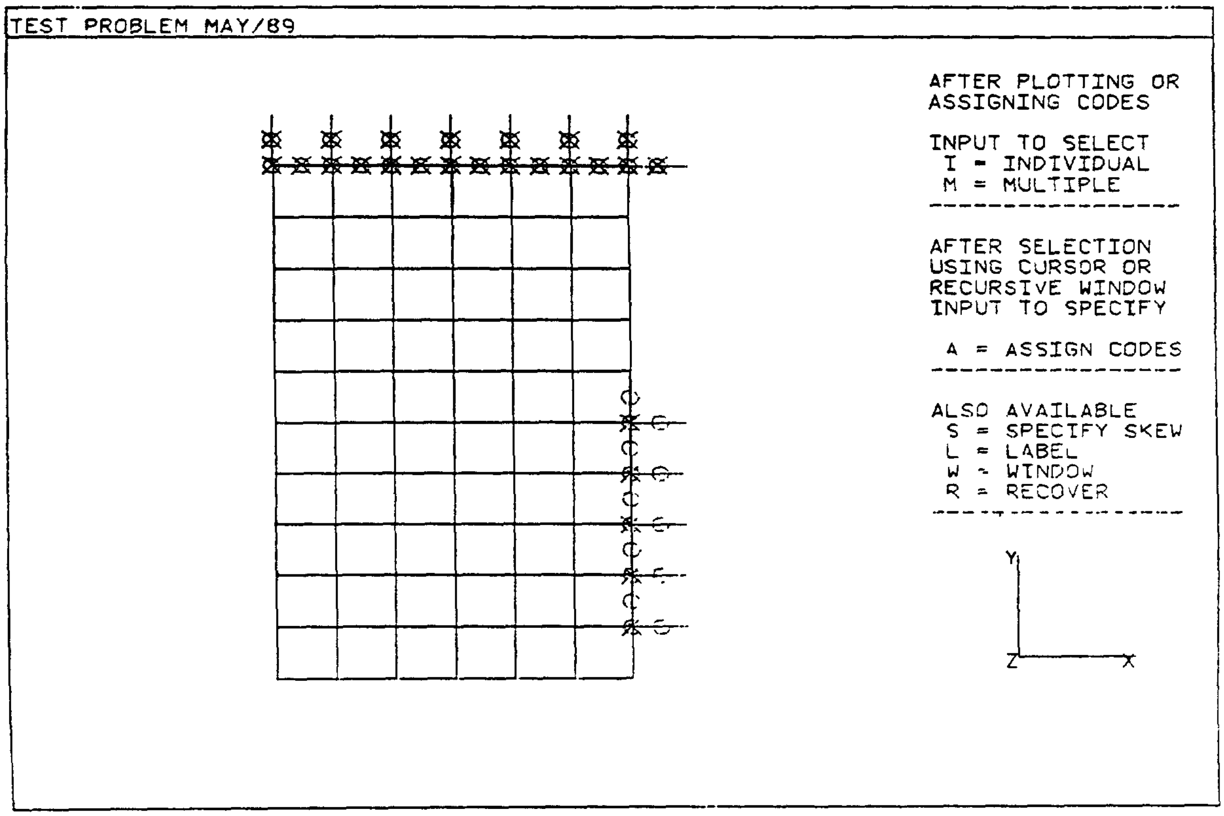

FIGURE 1: PLOT PRODUCED BY VASTBC

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A user's manual for the submarine pressure hull finite element model generator program SUBHUL is presented. SUBHUL has been designed to produce model, mass, boundary condition and load files for the finite element program VAST. The manual describes typical submarine geometry and structural details. Organization of the program is given along with the procedure for model generation. Hard copies of terminal session prompts and responses are included to illustrate the use of the program . The VAST input files produced by SUBHUL are described. Examples of stress, buckling and vibration analysis using VAST are provided with the results illustrated in the form of graphic output.

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